7 WASTEWATER REUSE FOR URBAN AND PERIURBAN AGRICULTURE IN YAOUNDE CAMEROON: OPPORTUNITIES AND CONSTRAINTS

D. Endamana[1], I.M. Kengne[2], J. Gockowski[1], J. Nya[2], D. Wandji[1], J. Nyemeck[3], N. N. Soua[1] J. N. Bakwowi[1]

[1]International Institute of Tropical Agriculture – Humid Ecoregional Center, (IITA-HEC), Yaoundé, Cameroon;
[2]Wastewater Research Unit, Faculté des Sciences, Université de Yaoundé, Yaoundé, Cameroon;
[3]Institute of Agricultural Research for Development (IRAD), Yaounde, Cameroon.

7.1 Summary

Studies were conducted in three urban and two peri-urban sites in Yaounde to highlight the importance of food production in urban and peri-urban settings and the associated public health hazards. In each site, the physico-chemical, microbiological and parasitological properties of irrigation water were analysed and a socio-economic survey of urban and peri-urban agriculturalists conducted.

The results show that water used for crop irrigation in the urban domain exceeds WHO bacterial and parasitic standards for unrestricted crop irrigation, in contrast to the peri-urban domain which met the standards. In the urban area, faecal coliforms and faecal streptococci are > 10^3 bacteria/100 ml and at least 33 % of the samples contained helminth eggs and cysts of protozoa. These wastewaters constitute therefore a potential source of health risk both for farmers of and consumers of the food produced in these milieus. Slightly less than half of the farmers interviewed attributed a health problem to their working environment. Among these farmers malaria, skin ulcers, bilharzia, typhoid fever and diarrhoea were the most frequently cited illnesses and the health expenses attributed to associate illness were estimated at approximately 62 Euros per year for each farmer. Furthermore, approximately 11 days of work are lost per year due to these illnesses.

Men (57 %) as well as women (43 %) were engaging in commercial agriculture. Farming is practised all year round, but is most intense during the dry season. Folon *Amaranthus hybridus,* zom *Solanum nigrum,* tege or këlëng- këlëng *Corchorus olitorius* and lettuce *Lactuca sativa* are the main vegetables cultivated both for commercialisation and consumption. Annual per capita income from these activities was estimated at 72 euro per year and 92%of the farmers interviewed fell below the poverty line. The majority (78 percent) of these agriculturalists cited no other economic activity. Land tenure was precarious, 30%were squatting, while 36%had either “borrowed” the land or were renting it from those with customary ownership. Only 20%were farming land to which they claimed customary land tenure. In a legal sense all were farming illegally as under Cameroon’s land laws all riverine property belongs to the state.

Despite their recognition of the health risks associated with urban agriculture, many farmers have no other options. As urban and peri-urban agriculture is increasingly gaining importance, especially in humid lowland areas, there is need to include and integrate this activity into urban and peri-urban development strategies, to educate farmers on risk management techniques, to improve coordination between health, agriculture and other services and to better manage municipal sewage.

7.2 Introduction

The importance of peri-urban and urban food supplies (particularly of the more perishable crops) has increased exponentially over the last two to three decades in West and Central Africa driven by rapid increases in urban populations and poorly developed rural infrastructure which spatially restricts supply. The most important portion of supply comes from irrigated agriculture in the urban and peri-urban inland valleys where the use of untreated wastewater is common (Cissé *et al*, 2000). These are intensive systems characterized by continuous cropping and high use of purchased inputs (chicken manures and pesticides) with relatively high yields (Gockowski *et al*., forthcoming; Assongmo 1990, Delville and Brucher 1996, Agendia *et al*. 1998).

The growing importance of this activity warrants its consideration in current strategies to eliminate poverty and reduce food insecurity. II (2002) survey results show that more than 18% of urban Cameroonians are living under the poverty line defined as living with less than 358 euros per capita per year (in contrast to over 50%of the rural population). Urban and peri-urban agriculture has been shown by Gockowski *et al*. (forthcoming) to provide earnings substantially above the minimum official wage (approximately 480 euro

per year) in the formal sector. However, there are health concerns both at the level of the farmers and the consumers of products derived from this environment. Untreated wastewater constitutes a medium for the development, proliferation and transmission of pathogenic micro-organisms and vectors of illnesses such as cholera, dysentery, bilharzia, and typhoid (Nduka Okafor 1985). This wastewater can also contaminate aquatic milieu with chemical pollutants and heavy metals (e.g. PCB mercury, lead, copper, and zinc) (USEPA 1992)

The site of this study, Yaounde, exhibits many of the typical symptoms facing urban agglomerations in West and Central Africa. Its population has grown in recent years at rates in excess of 7%per annum, and it is characterized by high unemployment. Another typical feature has been the rapid development of urban and peri-urban agriculture during the past 2 decades using urban wastewater for irrigation. There are however concerns over the polluted nature of the environment in which this activity is practised (Kengne *et al*. 2000).

The majority of urban households (81 percent) are supplied with water from the national water company SNEC, with approximately 34%of households in 1998 indicating running water in their housing compounds and 47%of households acquiring SNEC water from either neighborhood fountains or from their neighbor. In the past, water was acquired free of charge by households from neighborhood SNEC fountains but fountains are now controlled by private entrepreneurs who sell water at prices ranging from USD$ 1.5 to $8 m^{-3}. Nine%of households drew their water supply from wells and eight%from surface water.

Regarding the treatment of sewage, the city has never possessed a municipal sewage system. In the 1970s several small-scale sewage treatment plants were constructed to service certain agglomerations and industrial structures but these are no longer functioning (Agendia *et al*, 2000). Urban wastewater is handled in several fashions. The more affluent households utilize private septic tank systems with periodic pumping provided by the private sector. According to the most recent statistics, only 24%of households in 1998 had flushing toilets and septic tank systems. The majority of households depend on pit latrines for faecal waste disposal. Wastewater from bathing and washing enters into open sewer drains (*toutes dans les rues)*. Eventually all wastewater from the private septic drain fields, pit latrines and open sewers that characterize the sewage system of Yaounde flows into the inland valleys where they are then used to irrigate perishable horticultural crops.

This paper examines the livelihoods of urban and peri-urban agriculturalists and contrasts their exposure to health risks associated with the utilization of urban wastewaters. The distinction between urban and peri-urban agricultural sites is based on relative population pressures. Densely settled shantytown dwellings surround the urban valley sites, whereas the peri-urban sites are located on the edges of the city with much lower population pressure.

7.3 Study area and method of data collection

7.3.1 Site of study

The study was conducted in three urban and two peri-urban sites of Yaounde, the capital of Cameroon. Yaounde is undulating with altitude ranging from 700 to 850 m, and a hydrographical network of dendritic form (Kadomura, 1977). The study noted about 15 watersheds, each with a lowland watercourse being used for household activities like washing, fishing and agriculture. The high market demand for perishable leaf vegetables is not adequately met by production in the countryside because of a poorly developed marketing system and lack of refrigeration. As a consequence, the peri-urban and urban domains accounts for the bulk of the urban supply. The population is estimate at 1.5 million inhabitants (DSCN, 2001).

The climate is moist tropical, with abundant rainfall (1,500 to 2,000 mm yearly average) and constant temperature (25°C yearly average). Four seasons exist: long dry season (November – Mach): rainy season (March – June), short dry season (July – August) and long rainy season (September - November). The soil in the cultivated inland valleys is hydromorphic with a mixture of fine sand and organic material in decomposition.

A preliminary diagnostic was carried out to identify the exploitation sites of urban agriculture within the town. The size and characteristics of the five inland valleys selected for study are described in Table 1.

Table 1: Characteristics of Site of Studies

Lowlands	Characteristics		
	Area	Watercourse drained	Observations
Nkolbikok to Nkolbisson (Urban site)	64 ha	Abiergué	Anarchic discharge of solid waste and waste oil in the up stream. Important discharge of raw sewage from *Cité Verte* (residential quarter of about 15,000 inhabitants whose activated sludge treatment plant has been out of service for nearly 2 decades) Diffuse pollution coming from surrounding quarters Presence of some eutrophic ponds.
Kodengui-Ekounou (Urban site)	38 ha	Ake	Spontaneous densely inhabited quarter. Autonomous cleaning up with the aid of pit latrines Presence of latrines on pile near watercourse and excess evacuation channel of septic tanks.
Ngoa-Ekelle (Urban site)	3 ha	Olezoa	Pollution by waste-water from the University Campus and University Teaching Hospital whose activated sludge treatment plant have been out of service for more than a decade Presence of latrines with direct discharge to watercourse Other sources of diffuse pollution from neighbouring quarter Presence of series of eutrophic ponds at the stretch.
Emana (Peri-urban)	25 ha	Gonlo	Less populated zones Very much fewer sources of diffuse pollution
Oliga Peri-urban	6.1 ha	Mfoundi	Source of River Mfoundi Less occupied zone Private state land (near the Presidency of the Republic)

7.3.2 Assessment of the quality of water used for irrigation

To assess the quality of the irrigation water used, three samples from each site were taken during the long dry season (November-March 2001). Physicochemical parameters measured included pH, conductivity, color, suspended solids, nitrate, phosphate, and biochemical oxygen demand (BOD) along with faecal coliform and streptococci counts. In 2002 parasitologic analysis (helminth eggs and protozoan cysts) was conducted.

The physico-chemical and bacteriologic parameters were measured following standard methods described in Hach Handbook of Water Analysis (HACH; 1992). Helminth eggs and protozoan cysts were measured by the dysphasic separation technique (concentration and flotation) (Rodier, 1996).

7.3.3 Collection and analysis of socio-economic data

A socio-economic survey was conducted in the five humid lowland areas were the water quality was monitored. A purposive sample of 84 farmers present in their inland valley fields were interviewed using a three-page questionnaire by a team of Yaounde University students. The survey investigated the socio-demographic characteristics of farmers, their mode of land acquisition, the types of crops grown and gross crop revenues, cash costs for inputs, the type of water used for irrigation, and the major constraints among other things. Mean revenues per capita from agricultural production were calculated and the distribution compared with the poverty line in Cameroon estimated in the "*Enquête Camerounaise auprès de Ménage*" (ECAMII) (2002) at 358 euros per year.

Farmers were also asked to indicate whether or not they had experienced any health problems, which they felt were caused by their work in these inland valleys. Those who indicated in the affirmative were asked what illnesses they had experienced and to indicate the estimated health costs incurred.

7.4 Results and discussion

7.4.1 Characteristics of water used for crop irrigation

The average level of pollution was significantly higher in the urban sites as compared to the peri-urban sites lowland (Table 2). The concentration of pathogen indicators shows that in the urban sites, faecal coliforms (FC) were between one and two orders of magnitude above the WHO standard for non restrictive reuse of wastewater in agriculture (i.e., 10^3 bacteria per 100 ml), while in the peri-urban sites they are below threshold levels (WHO, 1989). The results on parasitology were similar. In the urban sites, sample contamination rates ranged from 33% to 100% versus no contamination in the peri-urban

sites. The WHO standard has a zero tolerance for both helminth eggs and protozoan cysts per liter of water destined to be re-used in agriculture.

As for organics pollution (BOD_5^-) and minerals ($N\text{-}NO_3^-$ and PO_4^{3-}) the concentration was relatively low due to the dilution effect. The presence of numerous ponds within the watercourse formerly exploited for aquaculture plays a significant role in the de-pollution of water.

The high level of microbiological and parasitological pollution found in water use for watering in the urban areas is clearly a result of not having a municipal sewage treatment service. Certain practices of the population are also problematic, notably direct defecation into the watercourse in the lowland area of Kondengui-Ekounou

7.4.2 Socio-economic aspects and land tenure

The socio-economic characteristics of farmers exploiting these lowland areas show that they are essentially young (mean = 38 years). Most of them are men (57%) although women were also involved (43%). The average family size is five adult equivalents. This represents an important source of labour. One third of the farmers (32%) indicated contact with either extension or health services. None reported belonging to any farmer organization.

The average area cultivated was 0.13 ha per farmer. That is similar to the result, 0.11 ha per farmer, reported by Endamana *et al*., (2001). The exploitation of lowlands is the principal activity of most of the farmers; only 22 % indicated earning revenue from extra-agricultural activities. These farmers are state employee (11%); seller (22%); stockbreeder (11%), technical task like joinery and masonry (28%)

Legally, riverine areas and their floodplains fall under state domain according to Cameroon land legislation. However, in most villages of southern Cameroon, customary tenure rights control these lands where user rights belong either to individual households or to the clanic kinship group (Diaw 1997). Nonetheless the legal uncertainties of land ownership especially in the urban domain could contribute to an underinvestment in water drainage control.

The most frequent modes of tenure rights were through squatting (30 %); inheritance of customary tenure rights (20 %); borrowing land from customary tenure holder (18 %); renting from tenure holder (18 %). Share cropping and buying were much less frequently cited (4 %). Similar modes of acquisition have been reported in other towns of the humid forest zone of Cameroon notably Mbalmayo and Ebolowa (Endamana *et al* 2000). Squatting occurs in particular on plots of land belonging to public institutions (e.g. National Institute of Agricultural Research in the low lands of Nkolbisson; the University campus at Ngoa-Ekele and the land near the Presidency of the Republic at Oliga).

With increasing demographic pressure, land problems have intensified; the arable land has become inhabited. Average distance between habitat and field plot was only 200 meters. Farms and farmers more or less share the same lowland environment, which could be a contributing factor to the high incidence of malaria cited by these farmers.

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Table 2 : Physico-chemical, microbiological and parasitological characteristics of watering waters

Parameters		Study sites (average ± standard deviation)					Acceptable limits (WHO, 1989)*
		Urban site			Peri-urban site		
		Nkolbikok-Nkolbisson	Kodengui-Ekounou	University. Yaounde I	Emana	Congress palais	
Physico-Chemical	pH	7,27 ±0.15	6.97 ±0.59	6,30 ± 0,67	7.26 ± 0.41	7.75 ± 0.13	n.a
	Conductivity (µS/cm)	343 ± 87	281±46	106 ± 33	104±29	71± 6	
	Colour (Pt-Co)	437± 248	404±24	541 ± 399	255±65	137±50	
	SS (mg/l)	52.7± 11,6	32.7±17	34,7 ± 9,9	18± 4,6	14±8	
	BOD (mg/l)	29.7± 13.3	17±7.5	17,7 ± 7,8	13.7 ± 6.4	9.7± 2.1	
	$N\text{-}NO_3^-$ (mg/l)	1.63 ± 0.45	1.2±0.1	0,7 ± 0,1	0.7±0,1	0.5±0.2	
	PO_4^{3-} (mg/l)	7,9± 6,9	3.3±2.7	4,5 ± 2,8	0.6 ± 0,6	0.6± 0.5	
Bacteriology	FC (UFC/100 ml)	1,30 ± 11,50 × 10^5	3.00 ± 1.11 × 10^4	8,85 ± 13,2 × 10^5	763± 270	319± 140	10^3 /100 ml
	FS (UFC/100 ml)	4,03± 3,79 × 10^4	2.83 ± 2.35 × 10^3	2,70 ± 45,0 × 10^3	583 ± 368	234±35	
Parasitology	Helminth eggs (% of sampling positive)	33,33	100	66,67	0	0	0
	Protozoan cysts (%of sampling positive)	33.33	100	33,33	0	0	0

* Limits for unrestrictive crop irrigation

n.a Not available

Table 3: Health problems perceived by those farmers indicating an association between illness and their agricultural work in the urban and peri-urban lowlands (n= 39).

Diseases contracted by farmers in lowland of Yaounde	Less inhabited (%)	Densely inhabited (%)	All (%)	F-test (p)
Malaria	67	52.	59	0.379
Rashes/Itching	44	5	23	0.003
Diarrhoea	6	0	3	0.286
Skin ulcers	17	19	18	0.852
Typhoid fever	17	0	8	0.053
Back aches	11	48	31	0.013
Respiratory problem	0	10	5	0.188
Bilharzias	0	19	1	0.052
Other health problems	6	14	1	0.384

7.4.3 Peri-urban and urban production and revenues

Most of the farmers interviewed produce several vegetables with three the modal value. Almost all (93%) of the producers grow *folon* (*Amaranthus* spp); 60% of farmers grow zom and nearly 40% cultivate Tege or Këlëng- Këlëng . In a study of urban consumption habits, Gockowski *et al*. (forthcoming) show that the urban poor disproportionately consume these three indigenous leafy vegetables. Other vegetables like lettuce *,* baselic *Basela alba*, gombo *Hibiscus esculentus*, poireau *Allium porrum* are practised by less than 20% of farmers. Lettuce takes on more commercial importance during the rainy season when the supply of indigenous leafy vegetables shifts from irrigated production in the inland valleys of Yaounde to the rainfed mixed food crop systems in the urban periphery. This is the only urban vegetable which is eaten raw. Supplies originating from the urban sites are at high risk of parasitic and faecal bacterial contamination.

Ninety-six percent of the farmers interviewed were producing vegetables for commercial purposes and only 4% exclusively for family consumption. Eighty-three percent also consumed a portion of their production, which was estimated at 18% of total production.

The mean net annual revenue per household from growing horticultural crops was estimated at 116,444 FCFA (equivalent to 178 euro) and the per capita income was 53,825 FCFA (equivalent to 83 euro). The distribution of income among these farmers indicates that 92% have earnings that lie below the poverty line, while 5%had revenues classified as intermediate and 3% cited revenues that would be classified as high according to the ECAMII (2002) income categories. These figures are indicative at best and are likely to be subject to under-reporting due to the sensitive nature of the question. It must also be remembered that 22%of the farmers indicated other sources of revenue earnings. Finally these figures are per capita household earnings only from the agricultural activities of the farmer interviewed. The earnings of the other household members was not determined. Despite these caveats, it is clear from these results that the farmers pursuing urban and peri-urban agriculture are in the main among the urban poor.

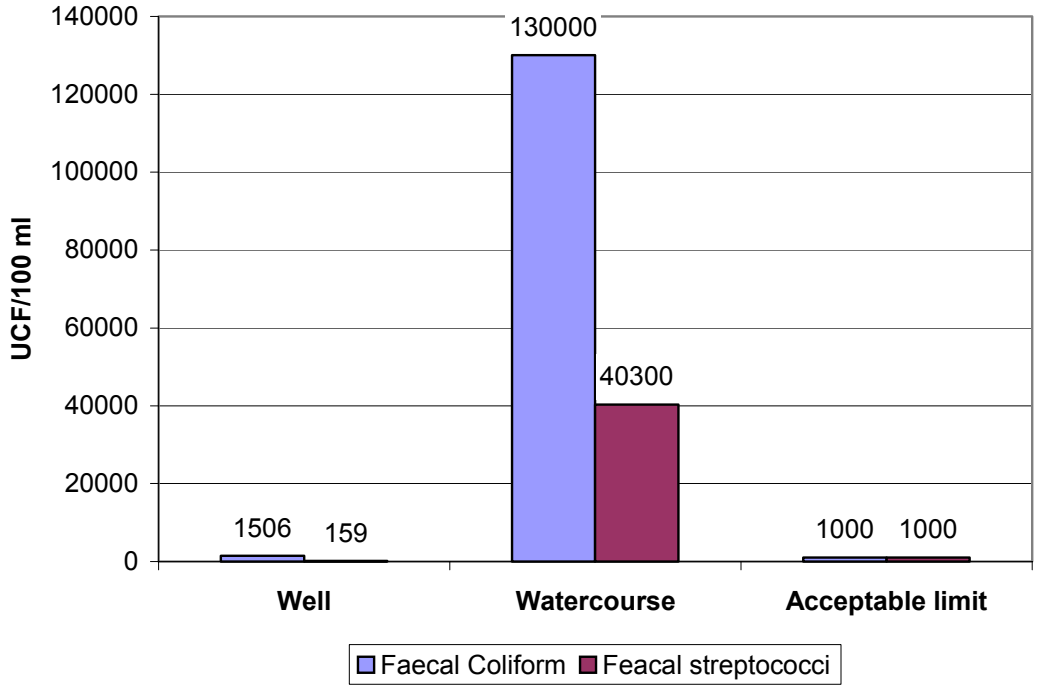
7.4.4 Water use: Typology and constraints

Hand watering the vegetables is the single most labour-demanding task facing these farmers. The most typical practice is to carry water in two 10 to 15 l watering cans. During the dry season these water demanding crops are watered daily. The use of mechanical means (motorized or manual irrigation pumps) for lifting the water was not reported. Average water volume used for watering crops depends on the surface area of the plot, the capacity of the soil to retain water and the plant. Most farmers used between 1-3 m^3 of water per week and used exclusively family labour to apply it.

The origin of the irrigation water depends on the topography of the site. Almost all the producers (99 %) use waters from watercourse running through the lowland valley. A much smaller percentage indicated acquiring water from a spring. Twenty percent of farmers dig shallow wells into the high water table on their farms, which reduces the distance they have to carry water and may also reduce some of the health risks of coming into contact with polluted water. Twelve wells and springs were assessed in Yaoundé in 2002 in another study (Ngnikam, 2002), and results show that although the water was contaminated for human consumption (faecal coliform) its quality meets WHO standards for streptococci and nearly meets the standards for faecal coliform (Figure 1). This suggests that there may indeed be some reduction in

health risk from digging shallow irrigation wells. Confirmation of this would require paired sample measures from the adjacent watercourse and the well and is recommended for future research.

When farmers were asked why they used inland water for irrigation, 43% cited its abundance, and a related 41% cited its proximity to their farms (plot). Fourteen percent cited its free availability while 5% indicated no other options. Twenty percent of the farmers perceive that these water sources are nourishing for the crops.



Source: Nynikam 2002 and data from this study

Figure 1. Comparaison of faecal coliform & streptococci (ufc/100 ml) from well and watercourse in high densely inhabitant on Yaoundé (Sources: Ngnikam, 2002, and study water sample survey)

When asked to cite their major water management problems and constraints, 68% indicated the high labour demand of hand irrigation; 15% cited the maintenance of drainage canals, 8% complained of flooding, 7% of leeches and 7% of water deficits.

7.4.5 Health impacts perceived by farmers

Concerning the potential sanitary risks link to water, Bontoux (1993) identified three categories of diseases:

- Diseases coming from drinking water and food directly or indirectly contaminated by irrigation water [diarrhoea and intestinal infection or non specific intestinal manifestations (hepatitis A)];
- Diseases from water in which they bath or with which they are in contact [skin infections, gynecological (candidiosis) or general (bilharzias, schistosomiasis)]
- Diseases from water near where people live [malaria, onchorcercosis, trypanosomiasis].

Forty-six percent of farmers perceived that they had experienced some health problem in the last 12 months, that they felt was associated with their agricultural exploitation of lowlands area and exposure to wastewater. Of the 39 farmers perceiving a related health problem (Table 3), 59% cited malaria, 23% reported skin irritations, 18 % reported skin ulcers, 10 % suffered from bilharzias, and 8% reported typhoid fever. Among those reporting work-related health problems, the average health cost was € 62 per year. Added to this cost, was an average of 11 working days lost per year. It's a high risk cost that has a negative effect on farmers' income. These costs are very high compare to an average expense in Yaounde of € 83 per individual and per year (DSCN, 2002).

Modes of transmission for malaria and typhoid fever may be related to the presence of farmers in the fields in the morning and evening where they have contact with mosquito, as well as the distance between the plot and the habitat which was only 200 m on average.

It is also worth noting that certain farmers complain of back pain (17%) and breathing problems. Breathing problems could be due to the ignoring of norms in pesticide utilisation. To manage pests and diseases, these farmers use a lot of pesticides. Gockowski and Ndoumbe (1999) showed that fifty-one%of the annual leaf vegetable horticultural cropping systems around Yaounde had applied pesticide. In a survey of agricultural supply shops in Yaounde, organochlorines classified by WHO as moderately hazardous Class II pesticides and carbamates classifed as highly hazardous class Ib pesticides were widely available (Gockowski and Ndoumbe 1999). In addition to the risk of acute poisoning in their application, farmers and consumers also face low dosage risk of cancer, and brain, liver, and kidney damage associated with chronic exposure from residues on crops.

7.5 Conclusion and recommendations

Urban and peri-urban agriculture in the inland valleys of Yaounde was shown to be mainly pursued by the poor. The study also showed that urban farmers come in frequent contact with water falling below the WHO health standards. The main contaminants were human bacteria and parasites. In contrast, peri-urban farmers use water that meets the WHO standards. The health risks and health costs of urban agriculture are high for poor families and techniques to minimize those risks are needed. One farmer practice—the digging of shallow wells in the valley bottoms for irrigating crops—may be effective in reducing these risks and warrants further investigation.

Consumers also face potential health risks from the use of contaminated water for washing vegetables before they are taken to market. This risk is particularly high for vegetables which are consumed raw such as lettuce. Public health messages recommended the soaking of such vegetables in chlorine solutions before consumption would help to reduce the public health cost of urban agriculture.

Farmers cited the heavy labour demands of hand irrigation as their major constraint. Low cost mechanical irrigation systems are available and in use in many parts of the developing world. The local manufacture of such devices is certainly within the realm of the capabilities of the small machine shops in and around Yaounde and should be pursued. Doing so would help to increase the dry season production of traditional leaf vegetables which are a major source of micronutrients and protein among the poor of Yaounde.

Urban and, in particular, peri-urban agriculture has an important role to play in the supply of perishable vegetable commodities. It can also be a significant source of employment especially among the poor, many of whom lack the human and financial capital resources required for employment in the formal sector. Despite the health risks which farmers themselves perceive, they still engage in these activities. Urban policy needs to recognize the importance of this subsector and seek ways to minimize the health risks while maintaining productive employment.

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