"Closing the rural-urban nutrient cycle"

Options for municipal waste composting in Ghana

Final Scientific Report on

IDRC project 100376

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Executive Summary

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1. Introduction and background

In Africa, the average population growth rate in urban areas is more than three times as high as in rural areas. According to UN projections, there will be in 2030 more than forty countries in Sub-Saharan Africa with higher urban than rural population numbers. Policy-makers have started to respond to this demographical shift. The major related challenge is the provision of sufficient food for the emerging mega-cities and appropriate urban sanitation. Both subjects could be linked in a win-win situation if the rural – urban "nutrient cycle" could be closed. The loop aims at nutrient recovery from organic waste for agriculture. If well planned, then the costs of waste disposal could be reduced. What appears like a logical win-win- situation is, however, seldom in the developing world.

To stimulate the discussion on nutrient recycling (composting) strategies, a pan-African conference was held in Accra in 1999, and the Canadian donor IDRC agreed in 2000 to co-sponsor a corresponding project to develop decision support for three Ghanaian municipalities (Accra, Kumasi, Tamale) on waste composting. The project was later on geographically extended to Ouagadougou (Burkina Faso) in order to get a cross-cut through more agro-ecozones along a North-South gradient reflecting variations in biomass production and organic waste generation, quality and availability, and use. Experiences from existing compost projects in Nigeria, Benin, Burkina Faso, Ghana and Togo were equally considered.

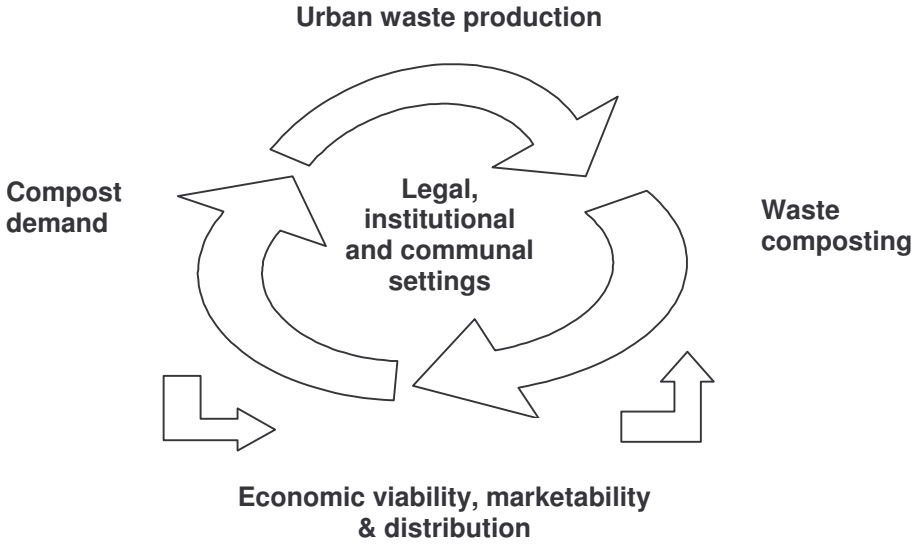
The project finally received French support allowing the construction of a pilot co-composting station in Kumasi, which is so far unique in Africa and allowed us to gain practical insights into compost station management and co-composting.

2. The Research Framework

A modified version of the recycling loop (see figure below) was used as project framework. It has the following five study segments:

1. The **supply** of organic waste (production, quality, quantity, time, availability, …)
2. The compost **demand** for food production (who, where, how much, when, perception, possible price, …)
3. The **process** of waste composting including the determination of appropriate technology (composting vs. co-composting, direct application of sludge, household composting etc.)
4. The **economic** analysis including profitability and investment analyses, and a comparison of the costs and benefits of composting vs. incineration and land fillings using a specific GTZ software.

5. **Legal, institutional and communal** factors affecting the set-up and sustainable management/ownership of compost stations.



Linking the results from the different study segments the optimal number and capacity of compost stations per city can be determined.

The methodological approach was described as a *'multidisciplinary situation and stakeholder analysis'* involving municipal authorities, especially the waste management departments, community leaders, urban and peri-urban farmers, researchers, private sector, etc. Through the collaboration with a large number of Ghanaian and European universities and more than 100 student projects about 5000 interviews were been carried out plus 2500 household surveys.

3. Results

The comparative survey of compost stations in West Africa was disappointing. Stations were generally poorly planned. Institutional and legal settings as well as compost marketing showed significant bottlenecks. Revenues from compost sales and organic waste collection did not cover the running costs and certainly not the [discounted] set-up costs of the stations (land, roof, cars, drums, etc). Due to the small size of the stations, any impact on reduced transport or health bills was considered negligible; the used software did not capture other social and environmental benefits.
Although we should not expect financially viable stations, the dependency on (public) subsidies and commitment makes most stations vulnerable and subject to production failure. Stations are apparently only viable where compost can be sold at a relatively high price while labour, capital, and land inputs

are free or marginal. This appears only possible in small neighborhood initiatives with identified compost demand.

The availability of sufficient organic waste will neither at this scale nor at any larger limit compost production also under consideration of seasonal variations and alternative uses (fodder, fuel etc) as the data from Accra, Kumasi and Tamale show. The analysis considered transport distances, waste quality and the actual capacity of the municipal waste collection services. The data showed that in all cities the largest share is household waste. However, market and industrial waste are usually more accessible for compost operators as their sources are concentrated in some few points, which would reduce transport costs. Laboratory analyses conducted on compost from Accra and Kumasi indicate relatively low levels of heavy metal contamination. Similar results are reported from other West African cities. Especially market waste combines a high percentage of organic matter (about 75%) and a low potential of metal contamination.

A comparison of waste generation and availability along a South to North gradient from Accra to Ouagadougou showed that with decreasing biomass production also the amount of organic waste and related nutrient content (standardized per capita) decreases progressively as dryer eco-zones are entered. In other words, where the need for organic inputs is high, there is less organic waste of good quality available from the same number of urban households. This might explain why towards the North farmers are increasingly resourceful in using waste as input, be it raw or composted.

Demand and supply: Economic considerations

There are two contrasting views how much compost is needed:

1. From the perspective of waste management, composting is principally reducing waste volume and transport costs. Compost production is therefore, even without any market, reducing the sanitation challenge and saving money, thus should be targeted at the largest scale possible. This is especially the case in a country like Ghana, where landfills are of significant public concern and increasingly far outside town, while compost stations could be set up close to the waste source.

2. On the other hand, over-sized stations are especially vulnerable to common arrears in subsidy payments. Thus a certain level of cost recovery appears healthy and requires an analysis of the compost market as well as station running costs. The general challenge we see from our survey is that potential/actual savings through composting are neither used to invest in composting nor to maintain existing stations. There is a significant gap between theory and reality as too often other budget gaps (have to) receive priority. The challenge would become even larger, if different public and private entities are in charge of compost station operations, waste collection, and landfill maintenance. This shows the need for a clear legal/financial framework describing tasks and duties.

The general consensus is to have a number of decentralized, low-technology but labour-intensive stations, with maximal one transfer point. A location in the city would be best to cut overland transport cost by half (50% of the waste will still need the landfill), although this might not favour compost marketing. The break-even volume per station was analysed to be around 30 tons of raw organic waste per day and station, i.e. nearly 10,000 tons of waste per year. This corresponds with a compost production of ca. 5000 t per station, which is about 1-2 times the capacity of the Pace Setter plant in Bodija, Ibadan.

From the perspective of compost sales and viability, the design capacity of a station should correspond with compost demand if waste supply is not the limiting factor. The study focused on actual and potential compost users (especially the different urban and peri-urban farming systems, UPA), their attitudes/perception towards the use of waste compost, as well as the quantification of the potential compost demand and its likely development under consideration of farmers' ability and willingness to pay (WTP) for compost and transport.

Farmers' generally positive perception of compost concerned both, a plant-growth enhancing (fertility) effect and soil amelioration. Large variations in the WTP were, however, recorded between different farming systems, urban versus peri-urban farmers, as well as between different cities with and without compost alternatives, such as abundant (and cheap) poultry manure.

The actual amount farmers were willing to pay was in general too low to finance the running costs of compost production except from relatively small groups, such as commercial pineapple growers/exporters around Accra. It was remarkable that the WTP expressed by farmers who already used compost was in several cases lower than among (still) non-users due to the unsatisfying performance of the currently available compost. While higher compost quality might raise the WTP, large quality variations among waste inputs will require e.g. (cost-raising) "blending" with faecal matter (see below) or mineral fertilizer. The small-scale production of quality compost for specific commercial clients could be an interesting venture for the private sector, without however reducing the waste problem to any significant amount.

The economic analysis showed that without subsidies, only few farmers, mostly in compost station vicinity, could afford to pay for compost and transport. Scenarios assuming a fully subsidized production still showed spatial limitations in compost dissemination due to transport costs. These limitations showed clearly that the idea to "close the **rural-**urban nutrient loop" is not realistic. While it is feasible to transport high value (food) products over long distances and different middlemen into the city, it is not feasible to transport a low value product the same way back.

Another reason is the abundance of shifting cultivation, which has lower (opportunity) costs than any soil intensification measures. Thus mostly urban and peri-urban agriculture (UPA) or plantations with no or very short fallow periods could benefit from compost application.

An important observation for compost marketing was that farmers in peri-urban areas have a higher WTP for compost than urban farmers.

A significantly higher demand for compost than from UPA was estimated from landscaping and estate development around the three cities, but especially Accra. The house-building sector is using "black soil" from local waste dumps (and farmyard manure) for garden design which is contributing to land degradation through topsoil mining where black soil is scarce. If compost use could become "mandatory" for all black soil suppliers of real estate companies, significant amounts of compost could be sold especially in Accra (35,000 tons/yr). Comparing different waste sources and quantities, market waste with the highest organic share and lowest contamination risk, could completely cover the analysed demand by UPA and estate development (Table 1).

Table 1: Demand estimate for compost considering ability and willingness to pay.

City	**Client group** **(RED = real estate developers; UPA = urban and peri-urban agric.)**	**New houses per year (estimated from diff. sources)**	**Total compost demand (t/yr)***	**Possible compost supply only based on market waste (t/yr)**	**Capacity of compost stations (examples for visualization)**
Accra	House-building (total)	27,000	260,000		12 stations of the Ibadan type (or one with the Teshie design capacity)
	RED share	ca. 13%	34,000		
	UPA demand		1,324		
	RED and UPA		**35,324**	**36,650**	
Kumasi	House-building (total)	9,000	85,000		One station like in Ibadan or 18 like the one in Accra James Town
	RED share	max. 2 %	1,700		
	UPA demand		942		
	RED and UPA		**2,642**	**30,000**	
Tamale	House-building (total)	2,000	19,000		Three stations like the one in Accra James Town or 12 Buobai stations.
	RED share	max. 1 %	200		
	UPA demand		262		
	RED and UPA		**462**	**950**	

* Based on a compost selling price of USD 5 per 50 kg bag to cover station running costs.

In comparison with agriculture, the real estate sector has in general higher quantitative but relatively low qualitative requirements as compost will mostly be used for lawns and ornamentals. Thus the real

estate sector could be the "favorite" customer group with interesting options for private-public partnerships and win-win situations as the first example in Accra shows. The financial strength of the estate sector could in this set-up even subsidize the (mostly lower) compost production for agriculture.

With respect to the required compost station capacities, it is possible to visualize the sizes needed by referring to other plants described in the main report (Table 1, right column).
In the case of Accra, the aggregate compost demand would absorb about 25% of the available organic municipal waste volume. The economic analysis compared a 25% scenario with 50%, 75%, and 100%. The high capital and land investment makes all of them non-profitable. In order of preference, the 25% option emerged as the one with lowest financial risk and dependency on subsidies. In view of waste (cost) reduction, higher percentages are recommended.
This also applies to the comparison of land-filling, incineration and composting: The overall cost of building and operating larger composting facilities in the Accra-Tema Metropolitan Area is much lower than for the other two options.
In all cases, however, subsidies from the public or private sector are necessary for any option of waste management, including composting, as collection fees cannot reach levels as in the developed world. Waste management authorities have, however, to focus their limited resources on the priority needs "waste collection" and "safe disposal" which consume more than half of the municipal budget, while cost recovery does not reach 15%[1]. Arrears in subsidy payments, political change or economic crisis can easily jeopardize the operation of compost station as of the waste management in general as many subregional examples show.
If subsidies for the maintenance of compost stations are uncertain, household composting will become an important option, and so related awareness creation. As children are traditionally in charge of waste disposal, they should be strongly considered in related campaigns. The reduction of the waste volume and collection cost through composting already at the household level was highly recommended in the expert consultation, although it should not be mandatory as low commitment could increase health risks for the whole community. The abundance of backyard gardens in Accra (50%), Kumasi (66%) and Tamale (25%) might offer an incentive for composting, in contrast to reduced waste collection fees (which are already low). The same potential of composting applies to peri-urban households where gardens or fields nearby are even more common. Simple compost technologies were tested around Kumasi in collaboration with the Royal Holloway University of London. Replications remained rare unless there was a direct benefit of the compost for backyard farming. A school awareness program in cooperation with EPA exposed pupils on-the-job to the

[1] Case of Kumasi, see table 1 in Introduction.

advantages of composting. This part of the program is considered worth replication under the national school curricula for science.

Another option, which requires little financial input – and saves landfill but not collection and transport costs – is the common mining of landfills or "bolas" (local waste dumps) after several months or years of natural decomposition. The product is the already mentioned 'black soil', which is traditionally a symbol of a high-quality soil (input). Landfill or bola-mining, would enhance their lifetime and allows nutrient recovery although it is not without risk of contamination. Zoning at the dumping site for controlled disposal of better waste here and poorer waste there could reduce risks. A two-container model for source separation in markets with food residues in one container, and plastics etc. in another, is being tested in Kumasi. A more difficult introduction of waste separation in households, which is without question a very useful long-term target, is not required from the compost demand point of view as argued in Table 1.

If subsidies are secured, it will depend on their volume, how many stations there could be. The economic analyses recommend stations below 30 tons of raw organic waste per day or ca. 5000 t of compost per year. With about 1,000 t of available organic waste in Accra per day, the number of such decentralized compost stations around the city center will range between 6 (to cover compost demand) to 33 (to reduce as much waste volume as possible).

With regard to the continuously increasing challenge of faecal sludge disposal in Ghana, options for co-composting solid waste with faecal matter should be considered. This would not only reduce the amount of sludge but can also improve the compost in terms of bulk density, texture and (via urine) its nitrogen content. Results from the Buobai co-composting pilot station using sludge drying beds show that this is not an easy task. Further research is necessary to improve co-compost quality, while reducing its production costs. An alternative is the use of settled sludge removed from sludge treatment ponds and mixed after at least 3 months of drying with compost from solid waste.

Institutional and legal analyses

The institutional analysis of stakeholders and policies of importance for the set up and operation of compost stations was carried out in detail in and around Kumasi, and from the legal perspective for all three cities. Further assessments were carried out for Ouagadougou and Tamale. This analysis appeared necessary, as compost projects have also been difficult to implement in the subregion due to poor co-ordination of efforts among institutions and stakeholders, weak institutional linkages and the lack of the enabling institutional framework, including clear legislation and policies.

The analysis showed that there is a myriad of – usually weakly implemented and enforced - policies and legislations governing environmental sanitation in Ghana. Since 1999, however, the national Environmental Sanitation Policy (ESP), drafted by the Government of Ghana, provides the national regulatory and institutional framework for all activities and actors involved in Environmental Sanitation. The policy supports composting for waste minimization, but does not (yet) include any larger section on composting.

Ghana's EPA published a corresponding guideline for stakeholder consultation and waste management planning, and promised to develop as soon as possible guidelines for composting which will give district assemblies an appropriate framework to draft related bye-laws. It is recommended to liberalize waste collection also for the informal sector (neighborhood donkey cars etc.) as seen in the subregion to facilitate community-based initiatives. A further gap is the lack of quality standards for compost used in crop production and landscaping. Finally, a byelaw urging the construction sector to use compost instead of topsoil would reduce environmental degradation and secure some cost recovery from compost production.

Institutional SWOT and perception analyses of possible roles in a compost project showed that composting of urban waste is an activity involving a large number of interest groups including different authorities, communities, district assemblies, NGOs, etc. The results of the surveys can be synthesized as follows:

1. Most key institutions perceive the utilization of organic waste as an agricultural input as positive and a good way to minimise waste. They were generally supportive.
2. However, most institutions are pessimistic about the likelihood of successful implementation of compost schemes due to different obstacles they see.
3. Lack of sufficient logistics, limited financial resources, and under-staffing are the major weaknesses of some key institutions. Strengths can be combined and weaknesses reduced by forming partnerships; therefore different partners are necessary for the success of a composting scheme.
4. Almost all stakeholders in peri-urban areas had knowledge gaps on waste management. These can be reduced, for example, by visiting existing demonstration projects in the country and abroad (e.g. in Ibadan).
5. In districts without Waste Management Department, severe communication gaps exist within and between the different departments/stakeholders presently trying to address waste problems. Only if it is possible to establish better linkages, a composting initiative can count on a supportive institutional environment.

Similar surveys among community leaders confirmed the general support towards composting initiatives, much in contrast to landfills. Compost stations are seen as a chance to improve sanitation and provide employment. Land could be made available, but the capacity of local institutions to

"enforce" community support is weak. The establishment of an independent CBO for running any project is therefore necessary. Local negotiations should consider in any case carefully if any promises to the concerned community are also budgeted. It might be strategically wise to run these negotiations through the CBO.

4. Key lessons

The following bullet points summarize the major lessons of this study:

1. The survey of compost stations in five countries of the subregion revealed the following reasons for failure or sub-optimal performance:
    a. Missing market and feasibility analyses resulting in unsustainable compost sales
    b. Missing crucial partners, resulting in unsustainable waste collection or compost production and marketing
    c. Missing (maintenance) funds after initial set up, resulting in financial and technical breakdown
    d. Missing legal frameworks and difficult land access, resulting in various conflicts

2. These lessons helped to propose a framework for a comprehensive feasibility analysis on options how to close the "rural-urban nutrient loop", considering different subsidy levels. The framework consists of five study segments. A first lesson was that closing the rural-urban loop is unrealistic. As compost is no high-value product (compared to food), transport costs would quickly raise too high. Thus it will only be possible to close the loop partially by serving urban and peri-urban farmers, but not rural ones except e.g. commercial export plantations.

3. The analyzed scenarios show that composting has clear advantages for municipalities and farmers without being automatically a mutual win-win situation. Municipalities need large waste volumes composted to reduce their spending on waste (collection), transport and deposal. Ideally this should take place in the city to safe as much money as possible. Compost sales are from their point of view a benefit, but not a necessary condition. Revenues would be anyhow low in comparison with savings through the reduction of the volume.

4. In fact, large sales are not likely due to the limited number of interested farmers in urban and peri-urban agriculture, and their low willingness to pay. However, especially in the Accra case, the real

estate sector could absorb significant volumes (even of average quality) and transform about 18% of the available organic waste into soil inputs for gardening and landscaping[2].

5. Win-win situations become more likely if privatization or private-public partnerships could be supported, for example, linking public compost stations and private real estate developers. This could also co-finance (subsidize) compost production for farming.
   Another immediate win-win situation for waste managers and farmers is the direct application of sludge on cereal fields under fallow as practiced in Northern Ghana.

6. The demand and supply analyses showed that already the municipal market waste would be sufficient in every city to satisfy compost demand, including landscaping. This means, if no subsidies are available to compost large waste amounts for waste reduction, the collection could focus on market waste, which is logistically easier/cheaper than going for household waste and technically of better quality.

7. Waste and compost contamination did not appear as a crucial factor as also reported from the subregion.

8. Waste management including composting is costly if done at any significant scale. Like in the developed world, it is hardly a profitable endeavor. This is even more the case where waste collection fees have to consider poverty and do cover less than 15% of the collection costs. Thus subsidies will be needed for everything including transport, land acquisition, set-up and maintenance of any compost station.

9. Ideally, savings in waste transport and landfill costs should be used to maintain compost stations. This requires that the Government or Municipality will not (have to) use the same funds for other priority areas. In all cases, where there is a risk that subsidies might (in volume or temporary) be limited, operational expenditures have to be kept minimal. Thus, a) only zero or low-technology options can be recommended to avoid accumulating debt and break down, and b) any option for cost recovery through compost sales should be used to reduce the dependency on the permanently constrained public budget. Compost prices, however, will be very low to compete with other organic inputs, which keep farmers' WTP low.

[2] Estate development, landscaping and farming together could absorb 20% of the available organic waste.

10. In the case of limited subsidies for compost production, it is crucial to carry out a quantitative demand analysis as well as a stakeholder analysis on (SWOT, roles and responsibilities) for station set up, operations and compost sale. Major prerequisites for long-term success and project sustainability are besides careful financial planning also effective project partnerships between public and private sector, the local community and where appropriate research institutions.

11. There are two geographically contrasting options for composting which do not need much public subsidies: a) composting at the household level, and b) controlled composting at the landfill site. The first one is reducing costs with every household joining the initiative but might not provide an aggregate amount of compost for sale or larger demands. The second option would provide a significant amount of compost, and enhance the lifetime of the landfill. The high percentage of urban backyard gardens in Ghanaian cities shows that composting at the household level should be promoted immediately to reduce the amount of waste at the source. The same applies to peri-urban areas, where the percentages can be even higher.

12. Household composting should not be mandatory as low commitment could increase health risks for the whole community. Its success requires a) an advantage for the household, e.g. the use of the product in backyard farming, and b) 'environmental awareness and know-how of the individual', which can only be fostered through well planned educational and training programmes starting in school to reach besides the next generation of decision-maker also the one currently in charge of household waste disposal. Reduced waste collection fees are no incentive as fees are anyhow low.

13. Waste management is not only challenged by the generation of solid waste but also liquid waste or excreta. Co-composting of solid and liquid waste is potentially a valuable and safe technique. However, it needs more research to gain a high quality product, and this if possible at a low price.

14. A market for high-quality compost exists, but is relatively small, especially where alternative soil inputs are at low price available, like with poultry manure around Kumasi.

The public discussion of the project results allowed a realistic assessment of options for composting. The transformation of the results and study framework into training modules (stakeholder analysis, demand analysis, economic analysis, etc.) for concerned stakeholders would further help to reduce the number of insufficiently planned compost projects.