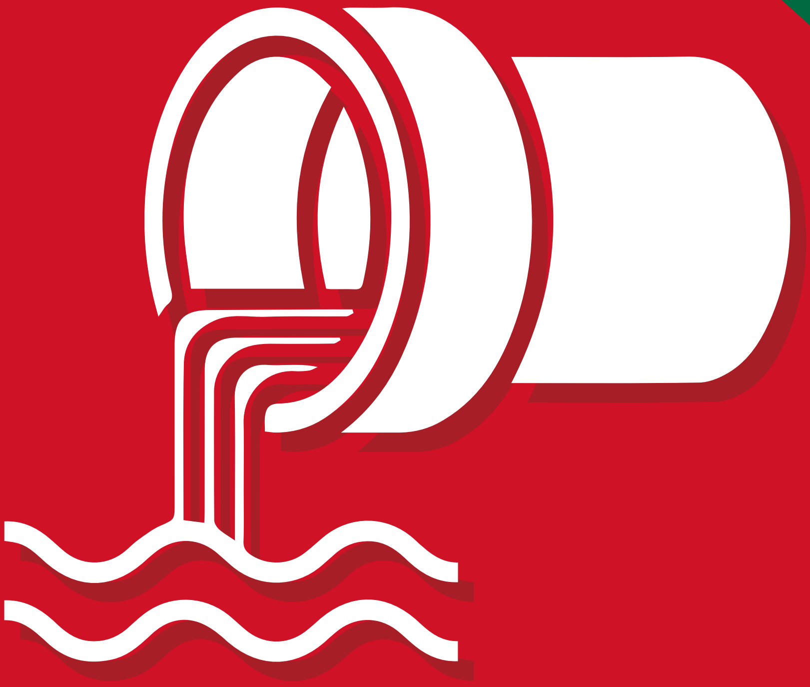

COST-BENEFIT ANALYSIS OF THE URBANISATION CHALLENGES IN ACCRA, GHANA

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Cost-Benefit Analysis of Urbanisation challenges in Accra, Ghana

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Academic Abstract

Overstressed by rapid, unplanned growth, Accra suffers from various risks including perennial flooding and exceedingly poor solid waste management. Inadequacies of drainage systems increase surface runoffs which also increase the risk of flooding. This calls for a comprehensive strategy, both in terms of tackling the existing hazards and preventing future deterioration. This study analyses 3 interventions aimed at overcoming the issue, namely construction of retention ponds, storm drain widening and community-led solid waste management. Construction of retention ponds leads to direct economic benefits of avoiding or reducing flood damage; and indirect economic benefits gained through less transport and business interruption – a total value stream of benefits equivalent to GHS 284 million over several decades. Drain widening not only reduces the extent of possible flood damages by 12% but also a reduction in diarrheal disease and averted productivity loss yielding a total benefit of GHS 379 million over several decades. Community-led solid waste management yields benefits through a cleaner environment within the community, improved health and reduced flooding over and above removal of waste from within premises, leading to overall benefits of GHS 6.4 m over a five-year period for a population of 50,000. The central BCR for storm drain widening was the highest at 1.8, followed by retention ponds at 1.3 and community solid waste management at 1.1. However, sensitivity analyses on the interventions demonstrate that the plausible BCR ranges for these interventions overlap substantially.

Key Words: Flooding, Retention ponds, Solid waste management, cost-benefit analysis, Drainage

Policy Abstract

The Accra Metropolitan Area (AMA) is suffering from a major urban infrastructure gap. The region's increasing economic growth, has triggered rapid urbanisation, characterised by expansion of built-up environment – roads, parking lots and other structures with impervious surfaces which do not allow water to infiltrate easily so as to replenish the water table. Accra suffers from risks including perennial flooding and exceedingly poor solid waste management (SWM) regimes (Amoako and Frimpong-Boamah, 2015). Inadequacies of drainage systems increase surface runoffs which also increase the risk of flooding. Further, the design capacity of some drains at downstream is not sufficient to safely discharge excess water to the sea. This is worsened by illegal dumping of waste which has become an accepted norm.

Saddled with decreased drains containment capacity due to siltation, solid waste piling up and lack of maintenance, Accra over the decade has suffered from perennial devastating flooding which is bound to increase in future (Songsore, 2017). This calls for a comprehensive flood risk mitigation strategy, both in terms of tackling the existing hazards and preventing future deterioration, either through conventional measures, which channel water safely to discharging outlets and bio-retention measures, which are natural solutions, designed to absorb the rainwater locally.

Ghana's developmental challenges are two interrelated enemies - poor environmental sanitation and drainage facilities. These localized, everyday hazards are greatly compounded by global-scale risks associated with increasing urbanisation of poverty (Turok & Scheba, 2018) and climate change dating back to the early 1930s (World Bank, 2019).

Intervention 1: Construction of Pantang and Haasto retention ponds

Implementation Considerations

Retention ponds are ponds designed with additional storage capacity to attenuate surface runoff during rainfall events consisting of a permanent pond area with landscaped banks and surroundings to provide additional storage capacity. The study proposes the construction of retention ponds in the middle and upstream of the Odaw basin to help temporarily store water from peak flood events and gradually release the same following storms.

Costs

The analysis covers a time period from 2018 to 2050, with investments occurring in the first year and ongoing operations and maintenance costs thereafter. Costs considered for this analysis were classified into initial investment costs and recurrent costs such as operations, maintenance and other dis-benefits.

Benefits

To estimate benefits from the ponds, the study utilizes the existing estimates of flood reduction conducted under the GARID project (World Bank, 2019) and benefits namely (a) direct economic benefits of avoiding or reducing flood damage; and (b) indirect economic benefits gained through less transport and business interruption. Totally, the present value stream of benefits is GHS 284 million of which expected value of flood reduction benefits is USD 20 million or approximately GHS 91m in 2018 figures.

Intervention 2: Planning for Drain Widening

Implementation Consideration

Even though drains reduce the local probability of flooding, technically deficient drains can result in faster run off in upstream areas and subsequently lead to the inundation of downstream in the basin. The intervention envisages constructing new (traditional) drains, especially if placed at bottleneck locations of the Akuapim hills as proposed (ie. Agbogba Happy Home-Alogboshie 13.55 km-stretch). The specification for the storm drain includes increasing its slope (with a steeper runoff) and changing the flow surface (to increase the drains capacity).

Costs

The construction costs for the storm drain have been assessed at the level of a conceptual design, using a bottom-up approach. The estimated cost of the construction of the storm drain were broken down by cost estimates for either dredging or constructing lined concrete of the delineated drainage area. The total upfront investment for the drain is GHS 124 million.

Benefits

Benefits are based on flood mitigation benefits from the drain - a 12% reduction in possible flood damages, equivalent to GHS 285m at an 8% discount rate. An additional important benefit of investing in a storm drains is the avoided death and illness from enteric diseases, a reduction in diarrheal disease of 30% and averted productivity losses. The benefits accruing from cases of diarrhoea avoided equals GHS 4.3m and increases with GDP growth in accordance with Ghana Priorities assumptions to a total benefit of GHS 72 million till 2050. The aggregated total benefit from this intervention is GHS 379 million.

Intervention 3: Community based Solid Waste management

Implementation Considerations

The CSM is a multi-sector planning approach geared towards service delivery in marginalised urban neighbourhoods: it integrates source separation of waste, collection, recycling/reuse and disposal; facilitates the incorporation of input from diverse actors and utilises the concept of urban zoning to enhance the implementation of a decentralised option. Under CSM, areas of high waste generation, like slums, markets, and stadia are identified and segregated. Each "camp" is then contracted out to a service provider who is to undertake constant waste collection and the overall camp management including sweeping, clearing of gutters and occasional fumigation to expel all rodents.

The analysis is conducted at a 'camp' level which we define here as 50,000 people. This is the level at which a given private entity would have responsibility to ensure operational waste collection services and cleanliness.

Costs

The upfront costs include the costs of nine tricycles, three skips and 6,250 bins for each camp. Upfront costs sum to GHS 1.2m per camp. Ongoing costs are also around GHS 97,000 per month or GHS 1.2m per year (these costs include the cost sweeping, scrubbing of pavement, desilting of drains and gutters, servicing of skip containers and disinfestation. The upfront investments (skips, bins and tricycles) are assumed to last for five years, and operational costs are assumed to increase with real GDP growth over the time period. At an 8% discount rate the cost of the intervention is around GHS 6.1m per camp over the five-year period.

Benefits

There are several benefits associated with improved SWM, foremost of which is the removal of waste from the area near the premises. Potential additional benefits include a general cleaner environment within the community, improved health and reduced flooding. Based on a review we estimate a benefit equivalent to GHS 1.5m per year for a given camp of 12,500 households / 3,125 compounds. Over a 5-year period, the present value of benefits is GHS 6.4m using an 8% discount rate.

Summary BCR Table of Interventions

Intervention	*Discount Rate*	*Benefit (millions, cedi)*	*Cost (millions, cedi)*	*BCR*	*Quality of Evidence*
Two retention ponds for Accra (Time period 2018-2050)	**5%**	**438**	**236**	**1.9**	**Limited**
	8%	**285**	**222**	**1.3**	
	14%	**153**	**204**	**0.7**	
Storm Drain Widening for Accra (Time period 2018-2050)	**5%**	**584**	**274**	**2.1**	**Limited**
	8%	**379**	**216**	**1.8**	
	14%	**195**	**161**	**1.2**	
Community Solid Waste Management for 50,000 people (Time period 2018-2023)	**5%**	**7.0**	**6.5**	**1.1**	**Limited**
	8%	**6.4**	**6.1**	**1.1**	
	14%	**5.5**	**5.3**	**1.0**	

1. Introduction

The Accra Metropolitan Area (AMA) suffers from a major urban infrastructure gap. The region's increasing economic growth, has triggered rapid urbanisation, characterised by expansion of the built-up area – roads, parking lots and other structures with impervious surfaces which do not allow water to infiltrate so as to replenish the water table. Against the backdrop that Ghana's annual public spending on infrastructure is exceedingly low, (an average of 2% of GDP in 2009 – 2015, compared to 5.2% in India and 8.8% in China) it is not surprising that Accra, the national capital has about 70 percent of its residents living in over-crowded and under-serviced slums.

Overstressed by rapid, unplanned growth, Accra suffers from various risks including perennial flooding and exceedingly poor solid waste management (SWM) regimes (Amoako and Frimpong-Boamah, 2015). Inadequacies of drainage systems increase surface runoffs which also increase the risk of flooding. Further, the design capacity of some drains at downstream is not sufficient to safely discharge excess water to the sea. This is worsened by illegal dumping of waste which has become an accepted norm.

Saddled with decreased drain containment capacity due to siltation, solid waste piling up and lack of maintenance, Accra has often suffered from perennial flooding which is only bound to increase in the future (Songsore, 2017). This calls for a comprehensive flood risk mitigation strategy, both in terms of tackling the existing hazards and preventing future deterioration, either through conventional measures, which channel water safely to discharging outlets or bio-retention measures, which are natural solutions, designed to absorb the rainwater locally.

Urbanization typically brings economic dividends which frequently translates into improved wellbeing in the medium to long term. There is a need for inclusive, long-range planning which will lead to meaningful urban development (Oteng-Ababio et al, 2020). Ideally, new forms of devolved governance are warranted, including adopting a more participative involvement of civil society groups and city populations.

Ghana's developmental challenges particularly in urban areas include poor environmental sanitation and drainage facilities. These localized, everyday hazards are greatly compounded by global-scale risks associated with increasing urbanisation of poverty (Turok & Scheba, 2018) and climate change dating back to the early 1930s (World Bank, 2019).

These have resulted in strikingly large rainfall-related floods particularly in 1955, 1960, 1963, 1973, 1986, 1991, 1995, 1999, 2001, 2002, 2010, 2011 and 2015 (Rain et al. 2011; Songsore, 2017). Multiple vulnerabilities exist with regards to floods and storm surges with further intensification of factors such as inadequate flood management practices to poor SWM, and local climate change and globalization processes (Appeaning-Addo et al. 2011).

Various studies have attributed the severe perennial flooding of Accra to its low-lying location and its massive spatial growth, the consequence of which include large impervious surfaces which affect infiltration (Arnold et al. 1996; Yeboah 2003; Afeku 2005); increased informal residential development (Aryeetey-Attoh, 2001); poor SWM practices as well as the poor physical planning and visible technical flaws in the urban drainage network as a whole (Karley 2009). The inadequately sized culverts, and blockage of the major drains by accumulated silt caused by years of neglect and lack of maintenance account mainly for the flood vulnerability in Accra (Nyameche, 2006). Meanwhile most of the policy initiatives of AMA have been ad-hoc in character, owing to a combination of factors such as limited public support and political liability most especially in election years.

Available data suggest that a total of almost GHS 0.68 and GHS 7 million Ghana have been spent on the construction and desilting (dredging) of the Odaw channel respectively between 2017 and 2019 (see Table 1).

Table 1: The annual amount spent on drains construction and desilting

Year	*Drains (Cost GHS)*	*Desilting (Cost GHS)*
2017	223,042	2, 304,002
2018	406,681	4,010,071
2019	60,304	761,555
Total	*690,027*	*7,075,628*

Source: Unpublished document from GAMA

In the words of Songsore (2017) ‘the 2015 floods in Accra was a wakeup call on all stakeholders’; […] The study cautions that the constant dredging of Odaw channel only addressed the symptoms of the problem, putting forth a solution before the root causes are known (Mosselson, 2018). Empirically, there seems to be lack of coordination between drainage designers and road engineers. There seems to be little mutual understanding or synergy of interest between city authorities and its physical and spatial planners (Massyn et al., 2015).

The Greater Accra Resilient and Integrated Development project (GARID), a World Bank and Ghana Government led project, which seeks to improve flood risk and SWM practices in the Odaw Basin, attests that the Greater Accra Metropolitan Area (GAMA) suffers from rain-related floods every year. Consequently, GARID supports the implementation of nature-based solutions like the development of flood retention basins. Our study agrees with GARID on the need for retention ponds but differs on the proposed location. We make the case for additional investments beyond GARID namely two additional retention ponds, and an additional drainage system. We further propose a demand-driven SWM model which hopefully, will minimize littering.

The increasing flooding incidences in Accra can be seen as a result of the rapid expansion of sealed-off surfaces, more especially with the increased impervious surfaces along the Akuapim hills thus reducing the absorption of storm water runoff. A retention pond close to the hill will tremendously improve the flood safety and living conditions of the low-income communities located in the downstream segment of the drainage basin, which suffer perennial flooding often limiting their development potential.

For the second intervention, we propose the construction of well-designed storm concrete drains, 5m wide by 3m deep, at the western part of the Akuapim Hills where all potential lands that could have been used for the construction of retention ponds have been encroached.

For the third intervention, we propose an innovative initiative for minimising solid waste mismanagement in Accra, which blocks drains. Our model is a demand driven and participatory approach which motivates community involvement. Our initiative, the Camp-Size model, is an alternative to typical SWM practice and promotes participatory processes where solutions result from inputs of all stakeholders and not solely from 'conventional wisdom' or 'prescriptive' planning.

The main result from our analysis is that all interventions pass a benefit-cost test in the base case. The central benefit-cost ratio (BCR) for retention ponds is 1.3, for drain widening, 1.8 and for community solid-waste management it is 1.1. Unfortunately, the evidence base that underpins these results is relatively weak with limited data available on key parameters such as the % flooding reduction associated with the first two interventions. Additionally, the cost-benefit analysis only considers direct and indirect benefits and does not take into account potential 'existence values' that may derive from the interventions. Given the uncertainty, we conduct sensitivity analysis on the interventions and identify plausible ranges, most of which span scenarios where net benefits are negative (i.e. BCRs below 1). For retention ponds we note a plausible BCR range of 0.5-3, for drain widening, for storm drain widening it is 0.8 to 3.5, and for community based SWM it is 0.7 to 3.5. Based on these ranges it is difficult to determine which of the interventions is preferred from an efficiency perspective. Additionally, in the context of the *Ghana Priorities* project it is unlikely that any of the interventions would be a 'top intervention' from a BCR perspective.

Conceptual framework

Given that Accra suffers from various risks including perennial flooding and exceedingly poor solid waste management (SWM) regimes it is important to map out an all-inclusive and cohesive approach to addressing these. Not only is the risk of flooding increased due to inadequacies of drainage systems which thereby increase surface runoffs, but the design capacity of some drains at downstream is not sufficient to safely discharge excess water to the sea. Both of the risks of flooding and poor solid waste management greatly impact the liveability and resilience of the city. Inadequate provision of solid waste management facilities in Accra results in indiscriminate disposal and unsanitary environments, which threatens the health of urban residents. Flooding causes damage to infrastructure and property and results in huge economic losses. The joint effect of these inadequacies and non-functioning services poses a threat to public health, ecosystem services, and economic growth, and thus affects the quality of life of the city's inhabitants.

In estimating the benefits of intervention strategies, this paper draws inspiration from the Total Economic Value (TEV) framework, which captures the diverse range of benefits of the intervention strategies. We focus on direct and indirect benefits for the purpose of this analysis. The benefits (direct or indirect) of urban flood management and solid waste management practices can span across various categories. Long-term direct benefits include lives and properties saved, protection of key investments, new economic opportunities, population benefiting from better drainage, solid waste management, and flood preparedness.

Indirectly the region would benefit due to the improvement in the living conditions and basic environmental services (including solid and liquid waste), reduction in water-borne diseases, reduction in poverty caused by disaster and climate risks and overall improvement in quality of life in most vulnerable communities.

In this analysis we do not consider existence values – i.e. the value ascribed to the benefit people will derive from the knowledge or satisfaction that the intervention exists and will continue to exist. While we were not able to verify in the literature, it seems highly plausible that there is little or no benefit derived from the knowledge that a retention pond or a storm drain merely exists, unlike say a forest or a species of animal. For solid waste management, we adopt a willingness-to-pay approach which should, in theory, capture existence values. To the extent that existence values can be attributed to the interventions, the BCRs presented here are underestimates.

2. Construction of Pantang and Haasto retention ponds

2.1 Description of the retention ponds

The analysis presented in this section was based on changes geared towards reducing the incidences of flooding in the Odaw basin. We propose the construction of retention ponds in the middle and upstream of the basin to help temporarily store water from peak flood events and gradually release the same following storms (World Bank, 2019). Retention ponds are ponds designed with additional storage capacity to attenuate surface runoff during rainfall events (Williams, Harrison and O'Hagan, 2012). They consist of a permanent pond area with landscaped banks and surroundings to provide additional storage capacity.

Technically, when retention ponds are well-engineered, they can provide both storm water attenuation and water quality treatment, while at the same time providing additional storage capacity to retain runoff and release same at a controlled rate. The ponds can be designed to control runoff from all storms by storing surface drainage and releasing it slowly once the risk of flooding has mitigated. In terms of operations, the runoff from each rain event can be detained and treated in the pond. The retention time (period) promotes pollutant removal through sedimentation, while aquatic vegetation and biological uptake mechanisms offer additional treatment. In principle, retention ponds should contain the following features (or zones):

- a sediment forebay or other form of upstream pre-treatment system (i.e. as part of an upstream management train of sustainable drainage components);

- a permanent pool which will remain wet throughout the year and is supposed to be the main treatment zone;
- a temporary storage volume for flood attenuation, created through landscaped banks to the permanent pool; and,
- a shallow zone or aquatic bench which is a shallow area along the edge of the permanent pool to support wetland planting, providing ecology, amenity and safety benefits.

There are some features which make the retention ponds safer, or more convenient. For example, a retention pond must include an emergency spillway for safe overflow when storage capacity is exceeded, a maintenance access, a safety bench, and an appropriate landscaping. According to Khan, Melville, Shamseldin, and Fischer, (2013), a well-designed and maintained pond can offer aesthetic, amenity and ecological benefits to the urban landscape as part of public open spaces. A World Bank (2019) document suggests that retention ponds can be effectively incorporated into parks through good landscape design.

Table 2: Geographical applicability in citing retention ponds

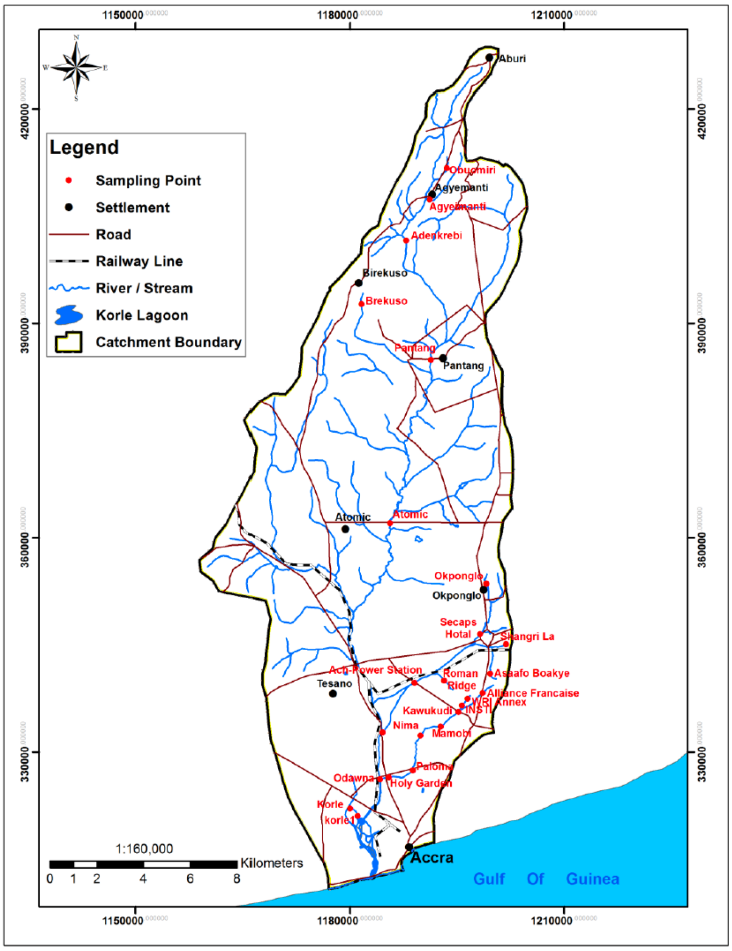
Land use	*Applicability*	*Evidence*
Artificial surfaces	Yes	Retention ponds are applicable to all artificial surfaces, subject to land stability consideration. Lining may be required where soil contamination may influence the water quality within the pond, which may be more likely in industrial areas.
Agricultural areas	Yes	Also applicable in agricultural areas, either to receive runoff from low permeability surfaces (e.g. tracks, farmyards, etc) or as part of the agricultural landscape (Environment Agency, 2012).
Forest and semi natural areas	Yes	Applicable as measures to store runoff in forests and semi-natural areas.
Wetlands	No	

Source: NWRT, 2013.

2.2 Description of Pantang and Haasto (Akomfe) retention ponds

The Odaw basin runs from the Aburi Mountains (latitude 5 52'N) down to Accra (latitude 32'N) where it discharges into the Korle Lagoon (Ansa, Sakyi, Asmah, Acheampong, and Lamptey, 2017). The river is located within longitudes 0 10'W and 0 15'W and consists of six streams namely; Ntare, Obommirem, Dakobi, Buade, Onyasia and Odaw, as well as two other streams running from East Legon and from behind Shangri-la hotel (Figure 1).

Figure 1: Pantang and Haasto Retention Ponds



2.2.1 Pantang Retention Pond

The proposed Pantang pond is within the Ga East Municipality which covers an extensive area of GAMA (about 85.7 km^2) and is evidently among the most deprived areas in the region (World Bank, 2017). Located at the northern part of GAMA, the municipality shares boundaries with Ga West to the west, La-Nkwantanang Municipality to the east, Accra Metropolitan to the south and Akwapim South District to the north.

With a 2010 population and housing census population of 147,742 (72,987 males and 74,755 females) the municipality bears the greatest brunt of water (flood) discharge from the Akwapim hills. Topographically, the land area consists of gentle shaped landscapes interspersed with plains in the west. The Akwapim range rise steeply above the western end and lies gently at 375-420 meters north of Aburi in the Akwapim South District.

The proposed pond is expected to have the following features:

- This is a natural wetland (see Figure 1) and takes its source from the Dakubi stream from Akuapim hills through Kpomkpo town, near the La Nkwantanang municipalities
- A major advantage is the fact that it is one of the furthest natural ponds (wetlands) at the base of the Akwapim hills.
- The size of the area is approximately 90,000m^2 though largely un-engineered.
- Its catchment areas (during overflows) include Agbokobi, Agbogba, and Abloagyei.

Due to a seemingly neglect of the natural habitat (floodplain-wetland), there has been some illegal encroachment on the site with author investigations indicating up to 20 individuals living in dwellings around the edges of the proposed pond area some 50-meters away from the center of the pond.

Figure 2: Pantang Pond

Source: Author's fieldwork (2019)

2.2.2 Haatso (behind Akomfe) Retention Pond

The Haatso village is also within the Ga East Municipality. Like the Pantang pond, the Akomfe size is also a natural pond, but is constantly being threatened by human encroachment as the

Assembly has not made any conscious effort to preserve it, in the very least, for encouraging peri-urban agricultural purpose.

- With this proposed pond, it is situated on the Ghana Atomic Energy Commission (GAEC) land at Haatso, close to the Transition funeral home. It is at the confluence of three (3) 'small' streams which serve as one of the sources of the Odaw River. The proposed site is approximately 20-acres (80, 937m^2) with scattered dwellings and uncompleted structures.
- Both geographically and topographically, the area has the potential of constructing canals to encourage commercial farming around the proposed pond site. Currently, farming is the major economic activity among the population surrounding the area, and among the range of vegetables they produced include pepper, tomatoes, cabbage, and okra.

3. Calculation of Costs and Benefits

3.1 General parameters and baseline

Each of the analyses covers a time period from 2018 to 2050, with investments occurring in the first year and ongoing operations and maintenance costs thereafter. Following *Ghana Priorities* standardized assumptions, discount rates of 5%, 8% and 14% were adopted for the cost-benefit analyses (Wong and Dubosse, 2019). All figures noted in this study are denominated in 2018 cedi unless otherwise specified. In calculating the cost-benefits of the proposed interventions, we acknowledge, and build on the comprehensive cost-benefit analysis prepared for the GARID project (see World Bank, 2019).

3.1.1 Calculation of costs

Costs considered for this analysis can be classified into initial investment costs and recurrent costs such as operations, maintenance and other disbenefits. The retention pond intervention in this analysis is compared to the situation in 2018. Population projection until the year 2030 has been taken into account, using projected population growth rates by country from the Ghana Statistical Service (GSS). Costs and benefits are presented in terms of equivalent annual value, based on the assumption that the targets are met by the year 2030.

Investment costs include planning, construction, land and addressing existing encroachment. Recurrent costs include operations and maintenance cost, ongoing protection and monitoring of pond sites, and continuous education activities. We also attempt to cost potential disbenefits associated with the ponds, namely increase in mosquitos and odour, with associated disease and inconvenience. This is of course an on-going problem, though our methodological approach to estimate this involves using a reduction in land values, which manifests as a one-off cost (the stream of future disbenefits of the nuisance is embedded in changes in land values).

Investment costs

The cost of the land was an estimation based on the current market price of land around the proposed sites and is valued at 220,000 cedi per acre. We apply this cost to the Pantang retention pond. Even though the land is public and would not need to be purchased, this accounts for the economic opportunity cost of not using the land for another purpose, or selling it. For the Haatso retention pond, we adopt this cost but multiply by two to account for the price premium associated with government attempts to reclaim land from private hands (personal communication, Hydrological Services Division, Ghana Ministry of Water and Sanitation).

The cost of constructing the pond was based on the assumption that an average pond depth is 2 meters, and follows a detailed costing review from developed nations (Aerts, 2018). This was reported as USD 22 per m^3 in 2015 figures and after applying the necessary PPP exchange and inflation adjustments, is equal to GHS 5.1 per m^3 of retention capability.

For upfront costs, we also assume a cost of removing dwellings and encroachment. We estimate this at GHS 2,000,000 for the Pantang retention pond - meant as a catch-all figure to account for human resources, incentives and other program costs. This figure is admittedly speculative and difficult to predict, though we note that for Pantang ponds there are no more than 20 individuals almost all of them living near the ‘buffer zone’ of the pond so the order of magnitude estimate seems reasonable. For the Haatso pond there are no such individuals, only abandoned half completed structures which can be left as is (primary investigation by authors).

Ongoing costs

There are several ongoing costs. Regarding operation and maintenance, Aerts (2018) notes an O+M cost of around 5%. However, discussions with the Ministry of Water and Sanitation indicate 10-20% maintenance cost for ponds is reasonable. We adopt 10% for this analysis as an indicative, typical value. This is only applied to the establishment cost of the ponds, and not to the land or dwellings removal.

We also include ongoing monitoring costs associated with protection of the property to prevent future encroachment. We estimate this at GHS 50,000 per pond per year, and is equivalent to roughly 3-4 full time employees. Another cost is for community education, which we estimate at GHS 3 per person living within the areas of the two ponds (170,000 near Pantang and 55,000 near Haatso). This is to ensure individuals do not throw waste or open defecate in or near the ponds.

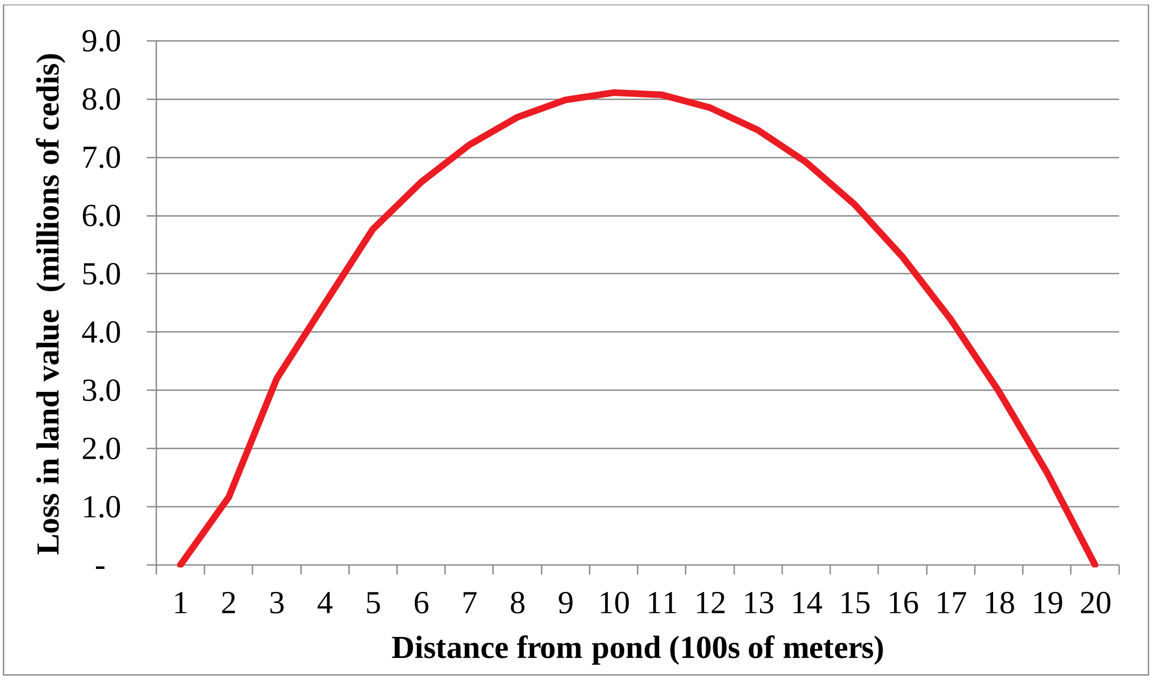
The last cost is for potential disbenefits associated with odour and mosquitos. To estimate the potential upper-bound cost of this disbenefit (which we call a 'nuisance cost'), we draw upon a study which estimated reduction in property values due to proximity to land fill sites in Oblogo and Mallam in Accra (Owusu et al. 2014). The reasoning behind this is that the disbenefits associated with landfill are similar to the potential disbenefits of being situated near a retention pond (smell, mosquito infestation), and that the economic value of this disbenefit is fully embedded in property prices.

Owusu et al. (2014) note that properties 2km away from landfill experienced a non-trivial reduction in property values. We therefore adopt a linear approximation that for every 100m closer to the centre of the pond property values reduce by 5%. To estimate the disbenefit, we calculate the land area of rings formed by concentric circles around the pond, each with radii 100m greater than the circle preceding it. To each ring a land value loss per m^2 is applied to calculate the total disbenefit.

Several adjustments are made to this model. Firstly, the ponds themselves are rather large with radii of around 160m. So we ignore land value loss associated with the first 160m around the pond since no one can live there. We also place a ceiling on the maximum loss at 75%, the idea being that even unfavourable land will still hold a minimum value. Lastly, the difference between landfill and retention ponds is that proper maintenance should mitigate some of the nuisance cost, and typically there is no such maintenance for landfills while for our analysis of retention ponds we assume some amount of maintenance. Nevertheless, there is a well-known maintenance challenge in Ghana, which means that upkeep should not be considered *a fait accompli*. To model this probabilistically, we assume that the nuisance cost is reduced by 50% compared to landfill.

The present value of the nuisance cost is estimated at GHS 103m per pond. The cost function follows a parabola with areas close to (far away from) the pond with high (low) loss per m^2, but relatively small (large) affected area. The loss peaks at 1km away from the pond. See Figure 3.

Figure 3: Nuisance Cost of Retention Pond



At an 8% discount rate this implies an annualized nuisance cost of GHS 9m per year over 33 years. The costs for each retention pond are noted below. Our analysis indicates that costs are GHS 222m of which 8% is upfront costs and the remainder ongoing costs. Nuisance costs make up the bulk of the cost of retention ponds.

Table 3 A: Baseline parameters, Pantang Retention Pond

Parameter	*Value*	*Remarks*
Size (ha)	9	
Retention capability (m^3)	180,000	Assume average pond depth is 2m
Establishment cost (cedi)	917,000	Based on Aerts (2018)
Land cost (cedi)	4,900,000	Based on current land prices in the area
Relocation cost (cedi)	2,000,000	Estimate
Nuisance cost (cedi)	9,000,000 per year	Inferred from Owusu et al (2014)
Surveillance cost (cedi)	50,000 per year	Estimate
O&M (cedi)	92,000 per year	Based on Aerts (2018)
Communication cost (cedi)	167,000 per year	Estimate

Table 3 B: Baseline parameters, Haatso Retention Pond

Parameter	*Value*	*Remarks*
Size (ha)	8.1	
Retention capability (m^3)	162,000	Assume average pond depth is 2m
Establishment cost (cedi)	825,000	Based on Aerts (2018)
Land cost (cedi)	8,800,000	Based on current land prices in the area with adjustment for cost escalation
Relocation cost (cedi)	0	Not required
Nuisance cost (cedi)	9,000,000 per year	Inferred from Owusu et al (2014)
Surveillance cost (cedi)	50,000 per year	Estimate
O&M (cedi)	82,000 per year	Based on Aerts (2018)
Communication cost (cedi)	483,000 per year	Estimate

3.1.2 Calculation of benefits

The June 3, 2015 flood disaster provided a compelling demonstration on the importance of mitigating flooding risk in Accra (Songore, 2017). To estimate benefits from the ponds, the study utilizes the existing estimates of flood reduction conducted under the GARID project (World Bank, 2019). That study adopted historical asset losses from the 2015 flood and hydrologically modeled flood reduction from the interventions.

The potential benefits were modelled probabilistically based on potential risk and flood damage from floods of different return frequencies. As rightly explained in the GARID project, and for ease of comprehension and interpretation of findings, the benefits of the perennial floods mitigation or improvements were classified into two main types: (a) direct economic benefits of avoiding or reducing flood damage; and (b) indirect economic benefits gained through less transport and business interruption.

Direct beneficiaries include families, businesses, and offices located within the Odaw river basin, while indirect beneficiaries are people living within the Metropolitan area, who will benefit from improved flood preparedness. Currently, close to 2.5 million people are living within the Odaw River Basin, and about 161,000 people at high risk of flooding from a 10-year flood within the basin (World Bank, 2019).

The conservative estimate of yearly average number of people who live in areas prone to 10-year flood return period and are affected in a flooding event with and without measures is about

61,000 (World Bank, 2019). The floating population passing through Kwame Nkrumah Interchange was estimated to be 1,000,000 in 2015, and approximately 10 percent were affected by flooding. Thus 100,000 transient beneficiaries could be included in the number of people will benefit, making the total 161,000 (Royal Haskoning DHV & SAL Consult, 2019).

Economically, about 40 percent of US$3.2 billion worth of economic assets currently at risk of flooding are in the Odaw Basin. A business as usual approach to the perennial flood risks in the Odaw basin, could significantly increase the annual average flood cost of flooding from US$34 million in 2018 to US$150 million by 2050 (World Bank, 2019).

Table 4 below presents the results of the GARID analysis of simulated damage without, and with the project based on different flood return periods and years. A calculation indicates that the expected value of flood reduction benefits today (the sum of the products of each category's probability frequency and flood damage) is USD 20 million or approximately GHS 91m in 2018 figures. In other words, GARID is estimated to mitigate about 60% of the possible flood damage in a BAU scenario.

Table 4: Simulated Damage with and without Project, based on Different Flood return periods and Years

Return Period	T1	T2	T5	T10	T25	T50	T100
Probability (%)	100	50	20	10	4	2	1
Damage in 2019 (US$)	3,106,837	6,785,364	28,087,308	114,779,960	334,770,432	537,949,184	754,783,808
Damage with project in 2019 (US$)[a]	2,197,172	3,896,216	9,838,076	20,549,516	95,787,380	212,506,474	435,126,451
Damage averted today	909,665	2,889,148	18,249,232	94,230,444	238,983,052	325,442,710	319,657,357
Damage in 2050 (US$)	10,777,380	24,591,624	85,723,424	238,216,672	519,688,704	761,336,256	988,148,096
Damage with project in 2050 (US$)*	5,650,776	10,492,296	24,373,216	60,101,744	189,745,516	392,169,012	649,555,136
Damage averted in 2050	5,126,604	14,099,328	61,350,208	178,114,928	329,943,188	369,167,244	338,592,960
Weighted probability	0.50	0.30	0.10	0.06	0.02	0.01	0.01

Note: a. Based on prevention methods for T10.

Source: World Bank (2019)

To estimate the benefits for this analysis, we assume further flooding reduction associated with the retention ponds beyond what is noted under GARID. This flooding reduction parameter is estimated at 12% of avoided costs under the BAU which is equivalent to 20% of the benefits under GARID. This figure was determined via expert opinion, by canvassing officials at the Hydrological Services Division in Accra at a workshop conducted at the Ministry of Water and Sanitation and via several face-to-face meetings. To the best of our knowledge there is no published literature upon which to base an estimate.

This figure is partially justified by the fact that the individuals around the ponds – 216,000 exceed the 161,000 beneficiaries that are assumed to benefit from GARID, by some margin. However, it is likely that the intensity of avoided flood would be lower for those immediately around the ponds. Furthermore, there would be even more benefits for the 161,000 due to the ability of the ponds to retain water upstream.

Based on this estimate, the present value stream of benefits is GHS 284m at an 8% discount rate. Compared against the costs, the BCR of the interventions is 1.3. At a 5% discount rate the BCR is 1.9. At a 14% discount rate the ponds do not pass a cost-benefit test.

Table 5: BCR of Retention Pond Intervention

Intervention	***Discount Rate***	***Benefit (millions , cedi)***	***Cost (millions , cedi)***	***BCR***	***Quality of Evidence***
Retention ponds	5%	438	236	1.9	Limited
	8%	285	222	1.3	
	14%	153	204	0.7	

3.2 Sensitivity Analysis

The quality of evidence for the parameters underlying the results is assessed as limited. The main parameters of interest – the flooding reduction benefit and the cost of nuisance from mosquitos and odour, are based on very limited evidence. Regarding benefits, this is partially due to the lack of even basic quantitative analysis for flood mitigation efforts in Accra, with the exception of GARID report. Regarding nuisance cost, this was based on a study from Accra. However, it was for landfills, which while somewhat similar to retention ponds, are obviously different along other dimensions. Even differences in area and time of analysis for the landfill study (conducted almost 10 years ago) threaten the external validity of such findings.

Because of this uncertainty is important to understand how these results might change under different assumptions or input data values. It goes without saying that in a developing country like Ghana, where prices of goods and services are very fluid, any cost-benefit analysis would deal with uncertainties regarding key (inputs) assumptions and future developments.

For the sensitivity analysis we vary key parameters to determine the impact on the BCR. The first parameter is the benefits impact. Given the uncertainty around this figure we examine two extremes i) the retention ponds are able to eliminate all residual flood damage in Accra beyond GARID as estimated by the World Bank and ii) our estimated benefits are a quarter as large. For these scenarios the BCR is 4.1 and 0.3 respectively, at an 8% discount rate.

Regarding nuisance cost, we vary the parameter by assuming that instead of 2km, the nuisance of mosquito and odour persists for only 1km from the pond or for 3km from the pond. In these cases the BCR is 3.9 and 0.6 respectively.

As a last test, we increase other investment costs substantially. For the cost of ponds we assume a 5x increase in establishment cost and relocation cost. In this case the BCR is reduced to 1.1. This shows that the result hinges greatly on the nuisance cost and the benefits assumption, and less so on other costs. The sensitivity analysis demonstrates that a reasonable BCR range for the intervention is 0.5 to 3.

4. Planning for drain widening

4.1 Description of intervention

Another infrastructure facility/service needed to complement attempts to reduce the incidence of flooding along the Odaw basin is the construction of well-designed storm concrete drains, that mirrors Alajo-Accra drain in areas like Agbogba Happy Home, through to Crossway Down, Taifa, Dome railways crossing, Hamburg School, Parakuo, Kissieman, Ayigbe Town and Alogboshie. The delineated area is approximately 13.55 km, primarily west of proposed Pantang-Akomfe retention ponds, south of Akuapim hills, and east of the Densu basin.

The communities and their corresponding drainage area can be characterized as an urban environment with predominantly impervious ground cover due to human activities. A significant contributor to the nuisance flooding is the wanton encroachment of wetlands and ramseyer sites in Pokuase and Taifa, coupled with the destruction of the forest cover on the slopes of the Akuapim hills for residential purposes.

The stretch serves as one of the most populous residential areas of Accra. The area is also an economic and educational hub for the city. Located within the boundaries is the Dome market, one of the biggest markets in Accra as well as a number of educational facilities including St Johns Grammer SHS; Achimota SHS; Hamburg Junior High School.

One key feature of this area is the Dome railway crossing which connects to Accra’s central business district (CBD). During rainy season, the area experiences nuisance flooding, which inhibits school and business activities. In 2018, there were at least, two reports of a child drowning. During these nuisance flooding events, the water from the drains overflows, covering the entire road spreading into shops and also causing vehicular traffic.

Rainy seasons generally overtop the existing bulkhead at areas along the stretch, which results in overland flooding of nearby streets and businesses. Coupled with increasing development along the drains, flooding events are expected to continue to increase in frequency and severity. Table 6 presents population of some of the selected settlements along the stretch.

Table 6: 2010 Population by sex (Kisseman, Dome, Taifa)

Settlement	*Male*	*Female*	*Total*
Kisseman	5,937	6,066	12,003
Dome	19,668	20,200	39,868
Taifa	17,103	18,248	35,351
Total	*42,708*	*44,514*	*87,222*

Source: Ghana Statistical Service, 2019

In general, maintenance relating to the dredging or repair of drains, is economically a low cost venture and within the reach of most local authorities. In the words of Pleijter, Udo and Mantey (2019) "a properly functioning drainage system is the backbone of flood prevention".

Even though drains reduce the local probability of flooding, technically deficient drains can result in faster run off in upstream areas and subsequently lead to the inundation of downstream in the basin (Pleijter, Udo and Mantey, 2019). It is a common practice to see dredged sludge being disposed next to the drains (see Figure 3). Such practice increases the likelihood of sludge flushing back into the drains and decreasing the effectiveness. This has been the bane of most drains in the basin, and a major cause of the perennial flooding (Ansa et al., 2017).

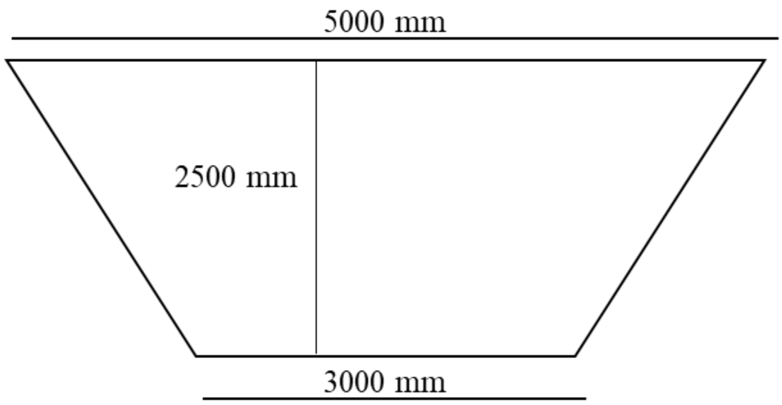
Figure 4: Part of the Taifa-Dome drainage channel to be engineered. This is an area around Taifa Obohene environs

Source: Author's fieldwork (2019).

Figure 5: Part of the Taifa-Dome drainage channel proposed for proper

Source: Author's fieldwork (2019)

Conscious of these externalities, constructing new (traditional) drains, especially if placed at bottleneck locations of the Akuapim hills as proposed (ie. Agbogba Happy Home-Alogboshie 13.55 km-stretch) is an effective measure to reduce flooding and the most preferred option. The specification for the storm drain includes increasing its slope (with a steeper runoff) and changing the flow surface (to increase the drains capacity) as follows:



At the conceptual stage, the storm drain is expected to have the minimum cover of reinforcement as 50mm, use concrete class of C25/20 with high yield steel, 460N/mm^2. It is estimated that, the proposed cost/m of the storm drain with its associated works would be GHS 9,834 depending upon the prevailing market prices of construction resources (Waste Care Associates, 2019). The proposed intervention, it is hoped will help mitigate the local flood issues in the mostly undrained neighbourhoods, albeit with some inherent difficulties. Such intervention though capital intensive (the costs are expected to be higher) than repair or maintenance, can also potentially increase the runoffs in downstream areas.

Figure 6: Part of the Taifa-Dome drainage channel proposed for proper engineering.

Figure 7: Sections of the Taifa-Dome (13.7 km) drainage channel proposed for proper re-engineering.

4.2 Calculation of Costs

The construction costs for the storm drain have been assessed at the level of a conceptual design, using a bottom-up approach. The estimated cost of the construction of the storm drain were broken down by cost items, which were quantified based on bills of quantity and unit prices as known from recent (2019) construction works in Accra. Tables 7 and 8 present the cost estimates for either dredging or constructing lined concrete of the delineated drainage area. The total upfront investment for the drain is 124 million cedi.

After implementation of the measures, operating and maintenance (O&M) costs are required to keep the measure functional over time. Under normal circumstances, flood reduction measures other than drains and/or retention ponds dredging do not require extra maintenance. However, in this case due to illegal human activities including building on the shoulders of the drains, it was deemed necessary to institute some level of O&M costs assumed here to be 5% of construction cost and increasing with real GDP growth. We also include communication costs for the estimated 100,000 people surrounding the drain. As with the previous intervention we value this at 3 cedi per person and increasing with real GDP growth. The total ongoing costs are substantial and equal ~100m cedi until 2050. The vast majority (95%) of the ongoing cost is attributable to maintenance with rest for communication.

Table 7: Proposed Dredging Locations/ Distance (km)/Cost Estimate

Location	*Approx. Length (km)*	*Cost Estimate (GH¢)*
Kwabenya ACP – Taifa	1.25	1,212,500
Taifa Obohene Down – Railway Bridge	2.00	1,940,000
Taifa junction – Dome Railway Station	2.35	2,279,500
Dome Railways – Dome Crossing	1.80	1,746,000
Dome Crossing - Kissieman	2.50	2,425,000
Hamburg School – Parakuo Junction	1.40	1,358,000
Agbogba – Happy Home-Haatso	2.25	2,425,000
TOTAL (km)	*13.55km*	*13,386,000*

Table 8: Proposed Construction of Lined Concrete Drainage System to alleviate flooding

Location	*Approx. Length (km)*	*Cost Estimate (GH¢)*
Taifa Obohene Down – Dome crossing	2.00	19,411,610
Taifa junction – Dome Railway Station	2.35	24,264,513
Dome Railways – Dome Crossing	1.80	17,470449
Dome Crossing – Kissieman	2.50	24,264,513
Hamburg School – Parakuo junction	1.40	13,588,127
Agbogba – Happy Home	1.20	11,641,966
TOTAL (km)	*11.25km*	*110,641,177*

Source: Authors estimates

4.3. Calculation of Benefits

As with the previous intervention we assess flood mitigation benefits from the drain. A similar approach – expert solicitation – indicated benefits of the same magnitude from the drain. That is a 12% reduction in possible flood damages, equivalent to increasing GARID benefits by 20%. This is equivalent to GHS 285m at an 8% discount rate.

An additional important benefit of investing in a storm drains is the avoided death and illness from enteric diseases. Labite et al (2010) conducted a bacteriological study and determined that 60% of all diarrhoea related DALYS in Accra are attributable to open, unclean drains. A storm water drain, properly maintained should alleviate some of this disease.

To estimate the burden of disease avoided we assume that the intervention would affect 100,000 people living around the drain. Drawing upon Global Burden of Disease data and regional level data for Greater Accra derived from MICS 2017, we estimate that the annual incidence of diarrhoea for this group to be 83,000 per year (see another paper in the *Ghana Priorities* series – Awuah et al., 2020 for detailed explanation of the calculation steps). The number of deaths per year is estimated at 6.7. The age-wise breakdown of these figures is presented in Table 9 below.

Table 9: Annual Incidence and Number of deaths by Age group (Diarrhoea)

Age group	*Population*	*Annual incidence of diarrhoea*	*Annual deaths from diarrhoea*
Under 5	12,730	12,730	3.94
5-14	23,472	23,472	0.27
15-49	50,722	50,722	1.15
50-69	10,435	10,435	1.37
Total	***97,360***	***82,292***	***6.73***

Due to the presence of the drain, we estimate a reduction in diarrheal disease of 30% corresponding to half of the attributable burden of diarrhoea associated with drains in Accra as per Labite et al. (2010). Table 10 below describes the potential benefits on diarrhoea cases that can be avoided with the storm drain construction. In short roughly 25,000 cases of diarrhoea would be avoided from the intervention.

Table 10: Cases of Diarrhoea avoided and Cost per incidence by Age group (Diarrhoea)

Cases of diarrhoea avoided per age group	*Number*	*Cost per incidence (GH¢)*
Under 5	5,242	93
5 -14	5,138	156
15 - 49	11,708	220
50 - 69	2,600	156
Total	*24,688*	

Source: Authors calculations’

Each avoided death is valued differently depending on the age of the individual. The welfare impact from an avoided case of diarrhea is assessed using the cost-of-illness approach following *Ghana Priorities* guidelines (Wong and Dubosse, 2019). The only study available from Ghana is Aikins et al (2010). That study estimated a cost of treatment for diarrhea of USD 4.10 and USD 98.8 for outpatient and inpatient cases respectively (2004 figures). These are translated to 2018 cedis using the appropriate inflation and exchange rate adjustments and equal GHS 57 and 1372 respectively. These represent only direct medical costs and do not include the cost of patient or caregiver time.

To these we add the cost of patient or caregiver time for each age-group. We estimate average duration of each diarrhea episode using Global Burden of Disease data. These equal around 5 days for all age groups, though are slightly higher for U5s (5.5 days). Productivity losses are assumed to be 50% of national average wages for 15-49 year olds following Ghana Priorities guidelines. For 5-14 year olds and 50-69 year olds productivity losses are 25% of national average wages. This accounts for the likely lower wage rates for these age groups. For 0-4 we assume no productivity loss since we assume each 0-4 year old requires a caregiver at all times, regardless of whether they are suffering from diarrhea or not. See Table 11 below for an overview of parameters used.

Table 11: Parameters used to estimate cost-of-illness per case of diarrhea by age group

	Days per case	*Productivity loss per case*	*Cost per case (no treatment seeking)*	*Cost per case treated (outpatient)*	*Cost per case (inpatient)*
Cost per case of diarrhea U5	5.5	0	0	57	1372
Cost per case of diarrhea 5-14	5.1	64	64	121	1436
Cost per case of diarrhea 15-49	5.0	128	128	185	1500
Cost per case of diarrhea 50-69	5.2	64	64	121	1436

Lastly, we assess the weighted average cost per case by taking average treatment seeking rates from MICs by region and assuming 6% of all cases are for severe diarrhea necessitating inpatient treatment as per Aikins et al. (2010). For those that do not seek treatment, we assume only productivity loss. For Accra, diarrhea treatment seeking rates are 18%. The calculated figures for each case of diarrhea are presented in Table 11 above.

The benefits accruing from cases of diarrhoea avoided equals GHS 4.3m and increases with GDP growth in accordance with Ghana Priorities assumptions. The total benefit is GHS 72 million to 2050. This figure does not account for population growth, which would increase the benefits over time. However, this figure also does not account for natural decrease in diarrheal disease as sanitation infrastructure improves with rising GDP. This would lower benefits over time.

Table 12 presents potential benefits from deaths that can be avoided with the storm drains construction. The intervention would result in 2 statistical deaths avoided per year.

Table 12: Potential Benefits of Deaths Avoided by Age group

Deaths avoided	*Number*	*Years of Life Lost avoided per death*
Under 5	1.18	65.2
5 -14	0.08	60.5
15 - 49	0.35	39.9
50 – 69	0.41	17.2
Total	*2.02*	

Using standard Ghana Priorities guidelines valuing each year of life lost avoided at 1.3x GDP per capita, the annual benefit is equal to GHS 1.3m. The total mortality avoided benefits are GHS 29 million to 2050. A summary of total costs and benefits is presented below. The results indicate that an 8% discount rate the BCR is 1.8.

Table 13: BCR of Storm Drain Widening

Intervention	***Discount Rate***	***Benefit (millions, cedi)***	***Cost (millions, cedi)***	***BCR***	***Quality of Evidence***
Storm Drain	5%	584	274	2.1	Limited
	8%	379	216	1.8	
	14%	195	161	1.2	

4.4 Sensitivity Analysis

The quality of evidence for the intervention is limited, mostly due to imprecision in the benefits. As with the previous intervention, there is limited evidence on the hydrological impacts from storm drains in Accra, and none from the particular storm drains envisaged. We assess the impact of this uncertainty by conducting several one-way sensitivity analyses.

In the first sensitivity analysis we vary the impact of the flooding benefits in a similar fashion to the previous intervention namely that i) the intervention can eliminate all residual flooding damages in Accra and ii) the intervention only reduces flooding damage by 3% instead of 12%. In these cases the BCR is 4.7 and 0.8.

In the second sensitivity analysis we vary the impact of the intervention on diarrheal disease assuming that i) the drains eliminate 60% of diarrheal disease in the surrounding area and ii) the drains eliminate 15% of diarrheal disease in the surrounding area. In these cases the BCR is 2.2 and 1.5 respectively. The smaller range resulting from this sensitivity analysis merely reflects the fact that flood reduction is the primary benefit under the intervention.

In the final sensitivity analysis, we vary the costs of the intervention utilizing i) a figure that accounts for 50% cost overrun and ii) a figure that assumes 10% reduction in costs. The BCR range is 1.2 to 1.9. Overall a plausible BCR for this intervention is 0.8 to 3.5.

5. Community based solid waste management

In developing countries, cities are experiencing population growth that far exceeds their absorptive capacity in providing conventional shelter, sanitation, and environmental protection due to their low capacity and limited resources (Shekdar, 2009; Owusu and Oteng-Ababio, 2015). This has led to a situation where waste is irregularly collected and illegally dumped without any treatment (Aye and Widjaya, 2006) causing groundwater pollution and river contamination by leachate, and methane gas generation that contributes to global warming (Christia and Thomas, 2010).

In Ghana, studies (Meiza et al., 2015; Oteng-Ababio, 2018) reveal that though city authorities have many policies on SWM, factors like weak legislation, lack of enforcement, corruption and lack of effective public participation, and inadequate governance frameworks constrain the establishment of a sustainable system. Not only have these challenges overwhelmed the authorities' containment capacities, but the situation is worsened with most residents living in unplanned and informal settlements where city authorities by-pass them and will not invest in infrastructure because they lack formal tenure, and are thus 'illegal'.

The result is an increasing gap between the 'haves' and 'have-nots' in basic services. Till date, there is hardly any visible success story; rather there are expensive programmes with limited reach that encourage subsidy dependency and discourage ownership. With unprecedented high public expectations (Meiza et al., 2015), the policy experiments remain incompatible with local realities and favour high-cost designs which are poorly targeted and hardly ever reach the poorest segments of the society (WSSCC 2009).

Recent emerging demand driven and participatory approaches do motivate people involvement and encourage the use of appropriate technology which better fits the realities especially in the informal settlements. They promote participatory processes where solutions result from inputs of local stakeholders and not solely from 'conventional wisdom' or 'prescriptive' planning (Atkinson 2007). We examine one such initiative, the Camp-Size model (CSM), as an alternative approach to the typical SWM practices to extract key lessons for improving service delivery in the growing complexities of the urban environment.

5.1 Description of intervention

The CSM is a multi-sector planning approach geared towards service delivery in marginalised urban neighbourhoods: it integrates source separation of waste, collection, recycling/reuse and disposal; facilitates the incorporation of input from diverse actors and utilises the concept of urban zoning to enhance the implementation of a decentralised option. The approach belongs to the communicative planning framework that focus on participatory, bottom-up methodologies where planners solicit the participation of a variety of stakeholders in a democratic planning process.

It provides a structured framework which goes beyond just waste collection to consider how waste is attracted from the generation points to the skip, with an eye on cost without compromising on quality and sustainability. The model responds to the desire for sound sustainable SWM, that goes beyond the traditional skip-picking to consider the fact that SWM should be socially, economically and environmentally acceptable. It contrasts current arrangements where service operators only haul waste containers to dumpsites without even sweeping the surroundings.

The CSM looks at the problems faced in household SWM, and cash in on the hitherto "lost opportunities" by putting in place modalities for the involvement of the public. The model upholds environmental sustainability concept based on circular resource management systems, and seeks to address environmental sanitation problems as close as possible to their source, and places emphasis on resource conservation and waste reduction.

Under CSM, areas of high waste generation, like slums, markets, and stadia are identified and segregated. Each "camp" is then contracted out to a service provider who is to undertake constant waste collection and the overall camp management including sweeping, clearing of gutters and occasional fumigation to expel all rodents. In terms of financing the operational cost is directly or indirectly passed on to all who reside in or patronize the services of the Camp in a form of crowdfunding. In low-income areas, lorry station or market, all the prospective beneficiaries may be mapped with the intent of roping them into "the funders' network".

The analysis is conducted at a 'camp' level which we define here as 50,000 people (the level at which a given private entity would have responsibility to ensure operational waste collection services and cleanliness). Data from the Maternal Health Survey (2017) indicates an average of 3.4 people per urban household. We adopt a value of 4 (four) to account for the types of household that would be the target of the intervention, namely low-income households. It is typical in urban Ghana for multiple households to exist within a compound and here we assume on average 4 households per compound. Therefore one compound has on average 16 people. We assume that waste collection services are provided at the compound level.

Individuals produce about 2L of waste per day (Oteng-Ababio, 2014), and therefore one compound produces 32L of waste per day. Each compound is provided with two 120L bins, one for organic and one for inorganic waste. This implies that each compound has to be visited around four times per month for periodic emptying. Operationally, this means collection once per week on a set day. Collection occurs via tricycle and each tricycle can reach 50 compounds in one day. In each camp there are 3,125 compounds and therefore, nine full time equivalent pickers on tricycles per day are required to fulfill waste collection requirements.

The model assumes local pickers collect the waste via tricycle and then partition the waste based on type. Sixty percent of the waste is organic and taken to a local composting plant (Oteng-Ababio, 2014). Of the remaining 40%, a quarter is valuable recyclable material and claimed by the pickers. The remaining non-organic, non-valuable waste is taken to skips, which are then transported daily to landfill site. For a camp of 50,000 people, 100,000L of waste is generated daily, of which 30,000L needs to be transported out to landfill.[1] Each camp therefore requires three 10,000L mega-skips.

5.2 Calculation of costs

There are investment and ongoing costs required from the intervention. The upfront costs include the costs of nine tricycles, three skips and 6250 bins for each camp. Upfront costs sum to GHS 1.2m per camp. The cost of the skips and bins are sourced from Alibaba.com and account for shipping. The cost of the tricycles is from Oteng-Ababio (2014) and inflated to 2018 figures.

[1] Note it is not the case that waste generated on a given day needs to be transported to landfill on the same day. In reality, seven days of waste accumulate in each compounds' bin before collection. The model is set up such that waste from 1/7th of the compounds are collected every day and therefore, the net effect is that 30,000L is transported to landfill.

Table 14: Unit and Total Costs of Bin per Compound

Requirements	*Number*	*Unit Cost (GHc)*	*Total Cost (GHc)*
2 x 120L bins per compound	6250	180	1,125,000
Skips	3	3500	10,500
Tricycles	9	1,800	16,200
		Total	*1,151,700*

Ongoing costs are also around GHS 97,000 per month or GHS 1.2m per year. The following provides a breakdown of expected costs. The vast majority of costs are attributable to removal of the skips. This should perhaps come as little surprise. The task of cleaning and collection can be accomplished by low-skill, low-cost labour. However, it is the removal of large collections of waste to a landfill site tens of kilometers outside the city that requires machinery and associated expense.

Table 15: Ongoing Costs

Activity	*Frequency*	*Number required*	*Labor cost per day*	*Machine / equipment cost*	*Times per month*	*Cost per month*
Sweeping	Daily	6	20		30.4	3,650
Litter collection	Daily	9	20		30.4	5,417
Scrubbing of pavement	Quarterly	4	20	1600	0.3	2,160
Desilting of drains and gutters	Weekly	4	20	200	4.3	3,813
Servicing of skip containers	Daily	3		900	30.4	82,125
Disinfestation	Quarterly	4	30	100	0.3	173
Total						*97,338*

The costs and labour requirements were sourced from interviews conducted with Zoom Lion, a Ghanaian waste management company. The upfront investments (skips, bins and tricycles) are assumed to last for five years, and operational costs are assumed to increase with real GDP growth over the time period. At an 8% discount rate the cost of the intervention is around GHS 6.1m per camp over the five-year period.

5.3 Benefits

There are several benefits associated with SWM, foremost of which is the removal of waste from the area near the premises. Potential additional benefits include a general cleaner environment within the community, improved health and reduced flooding. The benefits of SWM can be estimated using willingness-to-pay (WTP) metrics elicited from potential beneficiaries. There have been several studies estimating the WTP for SWM services in urban Ghana (Boateng et al. 2019; Alhassan et al. 2017; Awunyo-Vitor et al. 2013).

Boateng et al. (2019) surveyed 1,600 heads of households in four urban centers of Ghana – Accra, Kumasi, Tamale and Takoradi – on what they would be willing-to-pay for improved SWM services. Their results indicate that residents of Accra and Kumasi would be willing-to-pay GHS 2 more for better services, while residents of Tamale and Takoradi would be willing-to-pay between GHS 2 and GHS 10 for improved services (2017 figures). Higher WTP was correlated with higher levels of education, socio-economic status and being employed. Unfortunately, the study does not state over what time period the increased WTP is applied to though it appears to be a monthly cost.

Awunyo-Vitor et al (2013) surveyed 600 households in Kumasi and identified a WTP for improved solid waste management services of GHS 5 to GHS 10. The authors note that at the time of the study services provided by the metropolitan assembly were inadequate with large piles of waste accumulating in public areas. The WTP measure assesses the value of improvement against this baseline. As with Boateng et al. (2019), the study does not clearly state over what time period this payment applies to.

Alhassan et al (2017) surveyed 855 households in Tamale and Accra and identified a mean monthly WTP of GHS 5.82 for indigent low-income communities and 10.30 GHS for immigrant low-income communities in Accra. For Tamale low-income households were willing to pay GHS 5.11, while middle-income households were willing to pay GHS 8.26 (2016 figures). Higher WTP was associated with higher levels of education attainment, household income, satisfaction with current services and being female.

Oteng-Ababio (2014) assessed the willingness to pay of 920 households from the Greater Accra Metropolitan Area (GAMA), constituting 4% of its total population. In low-income areas, 65% of surveyed households were willing to pay GHS 1 per month while 56% households willing to pay GHc 2 per month. Only 8% households willing to pay GHS 5 per month. The modal monthly WTP were GHS 1.52 AMA, GHC 0.5 in Tema Municipal Assembly (TMA), and GHC 1.1 in Ga District Assembly (GDA). In middle and high-incomes areas, 100% of the respondents were WTP GHS 5 and GHS 6 respectively (all 2007 figures).

Amfo-Otu et al (2012) studied 5 traditional semi-rural towns in Akuapem North District in Ghana, surveying 300 respondents on their WTP for SWM services. Variables like mode of collection, occupation and age were seen to have a significant impact on WTP for waste collection with the mode of collection being most significant. The collection methods preferred by the respondents were communal collection (56.1%), followed by block (26.3%), kerbside (14.3%) and house-to-house collection (3.3%). Unfortunately, while the authors were able to determine the factors that influence WTP, they did not actually report the mean or median WTP from their sample.

Based on the literature review above, the highest quality and most relevant studies are Oteng-Ababio (2014) and Alhassan et al. (2017). In 2018 figures, the WTP for low-income communities are between GHS 3.1-9.4 in Oteng-Ababio (2014) and GHS 6.2 - 12.6 in Alhassan et al (2017). Based on this it appears a reasonable WTP metric for urban Ghana would be around GHS 10 per month per household or GHS 40 per compound.

Applied to the analysis, this suggests a benefit equivalent to GHS 1.5m per year for a given camp of 12,500 households / 3,125 compounds. Over a 5-year period, the present value of benefits is GHS 6.4m using an 8% discount rate.

5.4 Summary of costs and benefits

Based on the above exposition we conclude that the costs of the intervention are GHS 6.1m over 5 years per camp, while the benefits are slightly higher at GHS 6.4m. The BCR is 1.1 indicating that the intervention barely passes a benefit-cost test. A summary of the results at different discount rates is presented below. The results are presented per camp of 50,000 people.

Table 16: BCR of Community SWM

Intervention	*Discount Rate*	*Benefit (millions, cedi)*	*Cost (millions, cedi)*	*BCR*	*Quality of Evidence*
Community SWM	**5%**	**6.5**	**7.0**	**1.1**	**Limited**
	8%	**6.1**	**6.4**	**1.1**	
	14%	**5.3**	**5.5**	**1.0**	

5.5 Sensitivity analysis

It is possible that WTP might not capture all benefits experienced by beneficiaries if for example, they are not fully informed of the impacts of the service provided. To explore the extent of potential omitted benefit, we estimate the welfare impact of a reduction in malaria and diarrhea cases arising from the service. To the best of our knowledge, there is no evidence on the impact of improved SWM on these disease, so we speculate a 10% reduction for the purposes of the sensitivity analysis as a plausible figure, if perhaps towards the upper bound of effects. According to the Global Burden of Disease the rate of enteric infections and malaria cases are 136,000 and 19,555 per 100,000 respectively, while the death rate for the same diseases is 30 and 62 per 100,000. A 10% reduction in these diseases in the population of 50,000 would therefore lead to 1.5 diarrhea deaths avoided, 3.1 malaria deaths avoided, 6830 diarrhea cases avoided per year.

The welfare impact of these health benefits is assessed using *Ghana Priorities* standard approaches (Wong and Dubosse, 2019) and is equal to around GHS 3.5m per year. Adding this to the WTP benefit yields a central BCR of 3.5. While this is significantly higher than the estimate arising out of the main analysis, this shows that SWM is unlikely to be a top intervention across the entire *Ghana Priorities* initiative. For costs, we conduct a sensitivity analysis that increases costs by 50%. This might be due to cost over-runs, or more likely across multi-site intervention that some camps fail to properly implement the intervention driving up the costs per unit of benefit, however defined. A 50% increase in costs would reduce the BCR to 0.7.

6. Conclusion

Accra suffers from various risks including perennial flooding and exceedingly poor solid waste management. The risk of flooding is exacerbated by inadequacies of drainage systems which increase surface runoffs. A comprehensive strategy is necessary, both in terms of tackling the existing hazards and also preventing future deterioration. This study analysed 3 interventions aimed at overcoming the issue, namely construction of retention ponds, storm drain widening and community led solid waste management. Construction of retention ponds leads to direct economic benefits of avoiding or reducing flood damage; and indirect economic benefits gained through less transport and business interruption – a total value stream of benefits equivalent to GHS 284 million over several decades. Drain widening not only reduces the extent of possible flood damages by 12% but also a reduction in diarrheal disease and averted productivity loss yielding a total benefit of GHS 379 million over several decades. Community solid waste management yields benefits through a cleaner environment within the community, improved health and reduced flooding over and above removal of waste from within premises, leading to overall benefits of GHS 6.4 m over a five-year period for a population of 50,000. The central BCR for storm drain widening was the highest at 1.8, followed by retention ponds at 1.3 and community solid waste management at 1.1. However, sensitivity analyses on the interventions demonstrate that the plausible BCR ranges for these interventions overlap substantially.

Table 17: Summary BCR Table of Interventions

Intervention	***Discount Rate***	***Benefit***	***Cost***	***BCR***	***Quality of Evidence***
		(millions, cedi)			
Two retention ponds for Accra (Time period 2018-2050)	**5%**	**438**	**236**	**1.9**	**Limited**
	8%	**285**	**222**	**1.3**	
	14%	**153**	**204**	**0.7**	
Storm Drain Widening for Accra (Time period 2018-2050)	**5%**	**584**	**274**	**2.1**	**Limited**
	8%	**379**	**216**	**1.8**	
	14%	**195**	**161**	**1.2**	
Community Solid Waste Management for 50,000 people (Time period 2018-2023)	**5%**	**6.5**	**7.0**	**1.1**	**Limited**
	8%	**6.1**	**6.4**	**1.1**	
	14%	**5.3**	**5.5**	**1.0**	

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