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An analysis of the environmental health impact of the Barekese Dam in Kumasi, Ghana

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Abstract

Although dams have beneficial effects, they are also acknowledged as having serious environmental repercussions if they are not properly managed. The objective of this work was to examine the impact of the Barekese Dam in Ghana on the health status of three riparian communities downstream against a control. The environmental health status of the communities was analysed with reference to traditional endemic communicable water-related diseases in the catchment area, which were identified as malaria, urinary schistosomiasis, infectious hepatitis, diarrhoeal diseases and scabies. Case-control study was then conducted in the three phases of the dam (pre-construction, at the end of the construction and in the late operational phases) to analyse the health status of the communities as a function of the phases of the dam.

The results showed that the control community consistently had a much better health status than two of the riparian communities, which were closer to the dam in all the three phases. However, it had a better health status than the third riparian community, which was farthest downstream, only in the first two phases. This community maintained a fairly constant health status retrospectively and did not appear to have been affected by the presence of the dam. On contrary, the health status of the two communities in close proximity to the dam deteriorated in the late operational phase. The study therefore showed that there was a strong association between the presence of the dam and poorer health status of the downstream communities in close proximity to it.

Keywords: Dam; Environment; Health status; Impact analysis

1. Introduction

The need to incorporate Environmental Health Impact Analysis (EHIA) in project planning has been emphasised in various documents such as Agenda 21 of the Rio Earth Summit of 1992 (Dunlap et al., 1993). However, this has not been given adequate consideration by most governments, especially in the developing countries. This is evidenced by governments often allocating small amounts of their budgets to the health sector and big amounts to other sectors whose activities have serious environmental repercussions on human health (Hassan and Birley, 1999).

Most projects including dams, especially those in the developing countries, were constructed prior to the adoption of Environmental Impact Assessment (EIA). In the case where EIAs were even conducted, most often post-project audits and monitoring are rarely conducted (Culhane, 1993). Hence the adverse impacts of developmental projects are likely to affect most vulnerable social groups.

Ghana adopted the EIA in 1994 (Ghana EPA, 1994) about 22 years after the Barekese Dam, the major source of potable water in the Kumasi Metropolis, was constructed in 1972. The construction of the dam presumably lacked EIA requirements. Although its construction has improved the quality of life especially of people in the urban and peri-urban areas, its impact on the health of the riparian communities downstream who lack access to potable water still remains unknown.

The objective of the paper therefore was to analyse retrospectively, the environmental health impact associated with the dam.

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2. Materials and methods

2.1. Brief description of the study areas

The map of the study areas is shown in Fig. 1. The Barekese Dam (the second and the major dam constructed between 1967 and 1972) and the communities are located in the forest region in the Atwima District of the Ashanti region of Ghana. In the same area lies the Owabi Dam, the first, but smaller dam constructed between 1928 and 1932. Three riparian communities chosen for the study were Barekuma, Aninkroma and Hiawo Besease. Kumi, which is in the same geographical area, but not downstream was chosen as a control community. The locations of the study areas, the demographic characteristics of the communities and their relative distances away from the dam and their water source are presented in Table 1.

All the communities lack access to potable water. The main water source at Barekuma and Aninkroma is River Offin, whereas Hiawo Besease uses both R. Offin and R. Owabi. Kumi on the other hand uses the Aworo Stream, a small stream which is almost dry throughout the whole year, leaving a small pool of water in a valley in the forest. They are predominantly peasant farmers. The main crops cultivated are tomato, okra, African eggplant, cassava, pepper, plantain, maize and cocoa.

2.2. Epidemiological survey

Information on traditional endemic communicable water-related diseases in the district was first procured from one of the District Health Posts. These were identified as malaria, infectious hepatitis, diarrhoeal diseases, skin diseases mainly scabies and urinary schistosomiasis. A preliminary survey at the community level confirmed the endemicity of these diseases in the catchment area. However, urinary schistosomiasis was found to be non-endemic in the control community. The sample sizes required for the full-scale EHIA were calculated using a formula for sample size determination in Sanders (1990). This yielded 225, 214, 255 and 180 for Barekuma, Aninkroma, Hiawo Besease and Kumi, respectively, all equivalent to18 households in each community. A cluster sampling was then employed to select 18 households in each community.

Case-control studies (Brachman, 1979; Lilienfeld and Lilienfeld, 1980) were conducted to estimate the prevalence rates of the diseases using focus groups (Finsterbusch, 1995) in all the 18 households who had Traditional Ecological Knowledge (Kuhn and Duerden, 1996). The data were collected under the three phases of the dam, namely, pre-construction phase in 1966, at the end of the construction phase in 1972 and in the late operational phase in 1999.

To facilitate recall and to overcome the problem of poor memory associated with the methodology, the questions were linked to certain historic political events which occurred in the country and coincided exactly with all the phases of the dam. The pre-project phase coincided with the year in which the First Republic under the presidency of Dr Kwame Nkrumah of the Convention People's Party (CPP) was ousted by the armed forces and the police on 24th February, 1966 (GISD, 1994). The end of the construction phase coincided with the overthrow of the Progress Party (PP) in the Second Republic under the Prime Minister, Dr K.A. Busia on 13th January, 1972 by the armed forces (GISD, 1994; Boafo-Arthur, 2000). The late operational

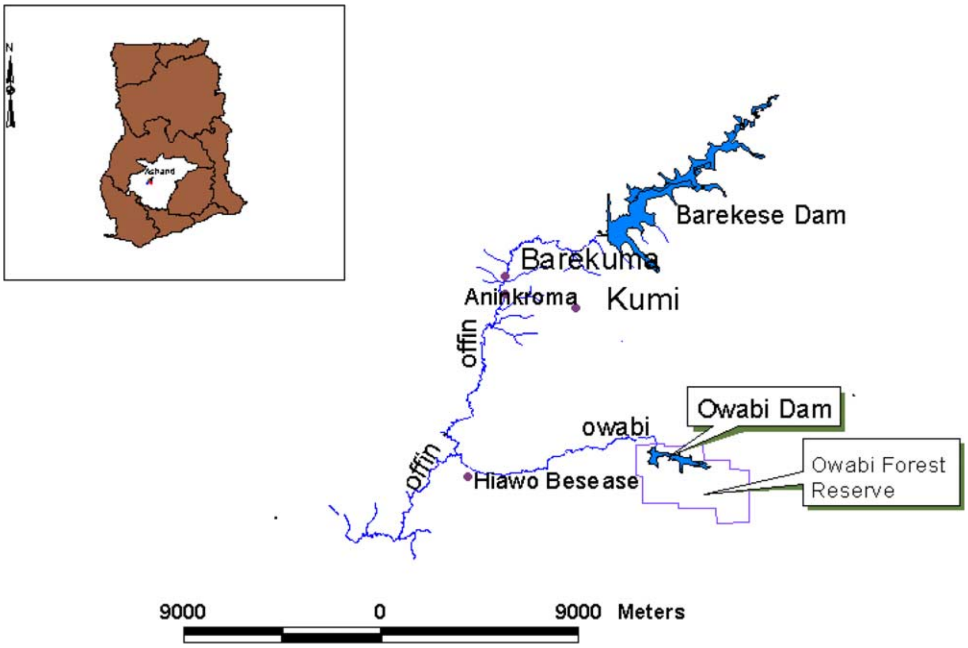

Fig. 1. Map of Ghana showing the study areas in Ashanti region.

Table 1
Locations of the study areas and demographic characteristics of the communities

Study areas	Locations	Bearings and distance from the dam (°/km)	Main water source (s)	Distance from water source (s)/km	Estimated populations			Estimated number of households 1999	Average family size 1999
					1966	1972	1999		
Barekese dam	6° 50′, 1° 44′ W								
Barekuma	6° 49′, 1° 46′ W	082°14′; 1.3 km	R. Offin	0.3	750	950	2000	140	14
Aninkroma	6° 48′, 1° 46′ W	072°21′; 1.5 km	R. Offin	0.4	620	850	1200	80	15
Hiawo Besease	6° 44′, 1° 47′ W	031°03′; 4.1 km	R. Offin	0.9	1200	1400	2500	160	16
			R. Owabi	0.3					
Kumi	6° 48′, 1° 44′ W	060°42′; 1.2 km	Aworo stream	0.2	170	200	600	40	16

phase coincided with the latter part of the second term of the Fourth Republic under the presidency of Flt Lt J.J. Rawlings of the National Democratic Congress (NDC).

3. Theory and/or calculation

Three theories applied for the estimation and evaluation of change in overall health status of the communities were:

(i) elements of impact descriptors (Clark et al., 1978; Rau and Wooten, 1980; Shopley and Fuggle, 1984),
(ii) weighted matrix model (Rau and Wooten, 1980),
(iii) warning system/red flags (Dee et al., 1973).

3.1. The elements of impact descriptors

The elements of impact descriptors (Clark et al., 1978; Rau and Wooten, 1980; Shopley and Fuggle, 1984) applicable to the work were:

(i) magnitude (M) that is, the size of the impact. In this study, M refers to the severity of the diseases which was based on degree of fatality (Tetteh et al., 2003);
(ii) importance (W) that is, the extent of the impact/number of people affected by the impact, action or project (Clark et al., 1978; Rau and Wooten, 1980; Shopley and Fuggle, 1984). In this study, W refers to the prevalence (spread/extent) of the diseases;
(iii) direction (nature) of impact, that is, whether the impact is adverse ($-$) or beneficial ($+$).

In this study, the direction was minus ($-$) since diseases have adverse impact on health.

3.2. Application of weighted matrix model

The weighted matrix model which makes use of weighting systems was adapted to incorporate the above impact descriptors. This model is given by $\Sigma\Sigma M_{ij} W_{ij}$ (Rau and Wooten, 1980) where, $M = (\pm)$ Magnitude of jth action on ith environmental variable, where the sign ($\pm$) is the direction of the impact whether beneficial ($+$) or adverse ($-$);

$W =$ Importance of jth action on ith environmental variable.

The application of this model therefore considered the relative magnitudes of the diseases based on degree of fatality on the health of the human communities as environmental variable. The relative importance of the diseases considered the extent to which each disease has permeated the population (that is, prevalence).

This model ensured that individual impacts of the multiple infections in each community in each of the three phases of the dam were converted into a common quantitative denominator through normalisation (Rau and Wooten, 1980; Julien, 1995). These impacts were then summed up to give a single or discrete value (Rau and Wooten, 1980; Julien, 1995), expressed as a quantitative weighted impact score (Rau and Wooten, 1980; Ortolano and Shepherd, 1995), representing an estimate of the overall health status of each community in each phase of the dam. The model therefore enabled the health status of the different communities to be evaluated and monitored.

The inherent subjective nature of the model was minimised by making use of the panel method in which Ms of the diseases were estimated using ranking, weighting and Delphi techniques (Rau and Wooten, 1980; Canter, 1996; Tetteh et al., 2003). The Ms were assigned weights on an interval scale of zero to ten (0–10) depending on the gravity of the diseases. The Ws were estimated using prevalence rates which were then transformed into weights similarly on a weighted scale of (0–10; Tetteh et al., 2003).

3.3. Application of warning system/red flags

The formula used in the determination of a negative change which constituted a warning system/red flag (Dee et al., 1973) is given by:

$$\text{Percent change} = \frac{\text{without project} - \text{with project}}{\text{without project}}$$

The rules in the warning system are as follows.

For ecological parameters:

Rule 1: Minor flag—if the percentage change is between 5 and 10%;
Rule 2: Major flag—if the percentage change is above 10%.

For all other parameters:

Rule 3: Minor flag—if the percentage change is less than 30%.
Rule 4: Major flag—if the percentage change is equal or greater than 30%.

Rules 1 and 2 were applied to calculate the change in the health status as a function of time since the quality of human health depends on the quality of the environment (Hassan and Birley, 1999).

4. Results and discussions

4.1. Multiple infections in the communities

Descriptive representations of the prevalence rates of the multiple infections in the communities in the three phases of the dam are presented in Table 2. These results indicate that there was a keen competition among the diseases over the years both within and among the communities. In order to obtain an estimate of the overall health status of each community the weighted matrix model (Rau and Wooten, 1980) was applied. It took into consideration disease fatality and prevalence. This model enabled a more direct and objective comparison of their health status.

4.2. Overall health status of the communities

The overall health status of the communities as a function of time is presented in Table 3. This was achieved by summation of the weighted impact scores of all the individual diseases in each of the three phases of the dam (Rau and Wooten, 1980; Julien, 1995; Ortolano and Shepherd, 1995), the negative sign indicating that the diseases have an adverse impact on human health.

4.2.1. Environmental baseline health status

The results from Table 3 show that the overall health status in the pre-construction phase at Barekuma, Aninkroma, Hiawo Besease and Kumi was −57, −53, −42 and −26 impact units, respectively. The results further indicate that the communities had poor health status. This observation therefore suggests that 'the natural environment plays an encompassing role, impacting on the infectious agent, the route of transmission, and the host (Brachman, 1979)', even in the absence of the dam. However, the health status of the control was by far better than that of the riparian communities. This could be attributed to a better herd immunity (Lilienfeld and Lilienfeld, 1980), non-endemicity of urinary schistosomiasis and perhaps, a better and different water source. The results also show that the adverse effects of the natural environment on the health status declined in the riparian communities downstream from Barekuma to Hiawo Besease which is in agreement with Julien (1995). The better health status at Hiawo Besease which had been associated with the adverse impacts of the first dam (Owabi Dam) for nearly forty years before the construction of the second dam (Barekese Dam) could be influenced 'by the overall immunity level of the population and by non-specific factors (Brachman, 1979)'.

4.2.2. Health status at the end of the construction phase

The overall health status of the communities at the end of the construction phase was −57, −55, −40 and −24 impact units for Barekuma, Aninkroma, Hiawo Besease and Kumi, respectively (Table 3). Applying Rules 1 and 2 of the warning system of Dee et al. (1973), the deterioration in the health status at Aninkroma was minor (−3.8%). There was no change in the health status at Barekuma (0%). On contrary, there were minor improvements in the health status at Hiawo Besease (+4.8%) and Kumi (+7.7%). The minor change at Aninkroma and no change at Barekuma suggest that the construction impacts of the dam could not significantly alter their health status as construction impacts are generally known to be less intense. The slight improvement in the health status at Hiawo Besease and Kumi could be linked to a gradual increase in the overall immune status of the community and by non-specific factors

Table 2
Period prevalence rates of water-related diseases in the communities as a function of the three phases of the dam

	Water-related diseases	Pre-construction phase (1966, %)				At the end of the construction phase (1972, %)				Late operational phase (1999, %)			
		B[a]	A[b]	HB[c]	K[d]	B[a]	A[b]	HB[c]	K[d]	B[a]	A[b]	HB[c]	K[d]
1.	Urinary schistosomiasis	20.8	8.5	23.2	0.0	21.6	9.8	19.5	0.0	44.5	40.0	26.2	1.1
2.	Malaria	33.7	34.7	16.3	22.6	32.3	37.9	16.5	24.2	32.2	39.6	21.1	42.2
3.	Infectious hepatitis	8.6	5.0	8.9	2.6	11.4	6.2	9.6	0.3	6.8	10.7	6.5	3.3
4.	Diarrhoeal diseases	15.8	19.2	12.8	3.2	12.9	16.7	12.6	1.8	11.3	22.2	7.9	16.1
5.	Skin diseases e.g. scabies	17.1	12.2	8.9	7.7	16.1	12.9	7.1	3.1	18.2	28.0	11.3	27.2

a, Barekuma; b, Aninkkroma; c, Hiawo Besease; d, Kumi.

Table 3
Health status of the communities expressed as quantitative weighted impact scores in the three phases of the dam

Water-related diseases	Pre-construction phase (1966)				At the end of the construction phase (1972)				Late operational phase (1999)			
	B[a]	A[b]	HB[c]	K[d]	B[a]	A[b]	HB[c]	K[d]	B[a]	A[b]	HB[c]	K[d]
Urinary	−4.0/2.2	−4.0/1.0	−4.0/2.4	−4.0/0.0	−4.0/2.2	−4.0/1.0	−4.0/2.0	−4.0/0.0	−4.0/4.6	−4.0/4.0	−4.0/2.8	−4.0/0.2
schistosomiasis	(−8.8)	(−4.0)	(−9.6)	(0.0)	(−8.8)	(−4.0)	(−8.0)	(0.0)	(18.4)	(−16.0)	(−11.2)	(−0.8)
Malaria	−7.9/3.4	−7.9/3.6	−7.9/1.8	−7.9/2.4	−7.9/3.4	−7.9/3.8	−7.9/1.8	−7.9/2.6	−7.9/3.4	−7.9/4.0	−7.9/2.2	−7.9/4.4
	(−26.9)	(−28.4)	(−14.2)	(−19.0)	(−26.9)	(−30.0)	(−14.2)	(−20.5)	(−26.9)	(−31.6)	(−17.4)	(−34.8)
Infectitious	−7.2/1.0	−7.2/0.6	−7.2/1.0	−7.2/0.4	−7.2/1.2	−7.2/0.8	−7.2/1.0	−7.2/0.2	−7.2/0.8	−7.2/1.2	−7.2/0.8	−7.2/0.4
hepatitis	(−7.2)	(−4.3)	(−7.2)	(−2.9)	(−8.6)	(−5.8)	(−7.2)	(−1.4)	(−5.8)	(−8.6)	(−5.8)	(−2.9)
Diarrhoeal	−6.5/1.6	−6.5/2.0	−6.5/1.4	−6.5/0.4	−6.5/1.4	−6.5/1.8	−6.5/1.4	−6.5/0.2	−6.5/1.2	−6.5/2.4	−6.5/0.8	−6.5/1.8
diseases	(−10.4)	(−13.0)	(−9.1)	(−2.6)	(−9.1)	(−11.7)	(−9.1)	(−1.3)	(−7.8)	(−15.6)	(−5.2)	(−11.7)
Skin diseases	−2.2/1.8	−2.2/1.4	−2.2/1.0	−2.2/0.8	−2.2/1.8	−2.2/1.4	−2.2/0.8	−2.2/0.4	−2.2/2.0	−2.2/2.8	−2.2/1.2	−2.2/2.8
e.g. scabies	(−4.0)	(−3.1)	(−2.2)	(−1.8)	(−4.0)	(−3.1)	(−1.8)	(−0.9)	(−4.4)	(−6.2)	(−2.6)	(−6.2)
Total weighted impact scores (overall health status)	((−**57**))	((−**53**))	((−**42**))	((−**26**))	((−**57**))	((−**55**))	((−**40**))	((**24**))	((−**63**))	((−**78**))	((−**42**))	((−**56**))

a, Barekuma; b, Aninkroma; c, Hiawo Besease; d, Kumi. Negative figures not in bracket are magnitudes (*M*s) of the diseases. Figures underlined are importance weights (*W*s) of the diseases. Negative figures in single bracket are weighted impact scores. Negative bold-faced figures in double brackets are total weighted impact scores (that is, the overall health status of the communities).

(Brachman, 1979). This was further consolidated by non-endemicity of urinary schistosomiasis at Kumi.

4.2.3. Health status in the late operational phase

The late operational phase marked a point in the life cycle of the dam where there were more drastic changes in the health status at Aninkroma and Kumi than at Barekuma and Hiawo Besease. The overall health status of the communities was −63, −78, −42 and −56 impact units for Barekuma, Aninikroma, Hiawo Besease and Kumi, respectively (Table 3). Applying Rules 1 and 2 of the warning system of Dee et al. (1973), the adverse impacts were major at Barekuma (−10.5%), Aninkroma (−47.2%) and Kumi (−115.4%). There was no change in the health status at Hiawo Besease (0%).

The adverse impacts in the late operational phase of the dam on the health status of the riparian communities closer to it were higher as compared to the situation in the baseline and construction phase, thus suggesting a deterioration in their health status. This observation is in agreement with Julien (1995) and Changming and Dakang (1986). However, these impacts declined after Aninkroma downstream to Hiawo Besease, the latter repeating its baseline health status (Table 3). Retrospectively, the relatively constant health status at Hiawo Besease could be explained in terms of maintenance of the same level of herd immunity (Lilienfeld and Lilienfeld, 1980) having been pre-disposed to the environmental health problems associated with the first dam (Owabi Dam) over the years.

The relatively poorer health status at Aninkroma compared to Barekuma, though the latter being closer to the dam than the former, was possibly due to higher exposure to community risk factors associated with a lowered immune status.

The sharp decline in the health status at Kumi in the late operational phase suggests a deterioration of environmental conditions at this place even though its water source has not been impounded. This was attributed to a very high weighted impact score of −34.8 impact units for malaria (Table 3). This score constituted 62.1% of the overall health status which could be attributed to three most important environmental factors (temperature, humidity and rainfall) which play important roles in malaria epidemiology (Ukoli, 1984). Notwithstanding this, Kumi consistently had a better health status than two of the riparian communities, namely, Barekuma and Aninkroma throughout the phases of the dam (Table 3).

Retrospectively, urinary schistosomiasis had not been endemic at Kumi at least up to the end of the construction phase. However, in the late operational phase the disease was detected which resulted in a weighted impact score of −0.8 impacts (Table 3). The disease was traced to two sources. These were:

(i) migration of one victim from Aninkroma to Kumi who was captured in the survey at Kumi;
(ii) schooling in which the victim is a citizen resident at Kumi but was schooling at Barekuma. This victim might have contracted the disease possibly through recreational contact with R. Offin at Barekuma or Aninkroma.

4.2.4. Strategic environmental interventions

The dam, which is the major source of potable water in the Kumasi Metropolis, supports many industries such as food, breweries, etc. In this way, the nutritional, health status and socio-economic status of people in the urban and peri-urban areas are sure to improve. Domestic activities and other economic ventures that make use of potable water can be sustainable to support the national economy. Since this facility is lacking in all the communities, it is therefore obvious that their socio-economic, health and nutritional status are adversely affected (Ukoli, 1984; Harinasuta et al., 1978), the riparian communities in close proximity to the dam, probably, the worst affected. Hence, the following interventions are recommended to improve the quality of life of the rural folks:

(i) provision of potable water is sure to wipe out infectious diseases that plague the tropics by 75% (Ukoli, 1984);
(ii) prompt chemotherapeutic treatment of infected people;
(iii) implementation of adaptable, holistic and sound environmental management practices reported extensively by WHO (1980, 1982) which consist of:
®environmental manipulations;
®environmental modifications;
®modification of human behaviour;
(iv) environmental health education programmes carried out properly at the community levels (Greene and Simons-Morton, 1984; Tones and Tilford, 1994).

5. Conclusion

A comparative analysis of the health status of the riparian communities with the control revealed that there was a strong association between the presence of the dam and poorer health status in the downstream communities closer to it than the control which uses a different water source. However, the impact of the dam on the health status tended to decline with distance downstream.

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