日本雨水資源化システム学会
第 17 回研究発表会
講演要旨集

2009/10/31～11/1

アートシアターいしかわ
石川県金沢市片町 2-2-5/〒920-0981

Proceedings of the 17th Annual Congress of Japan Rainwater Catchment Systems

JRCSA

◆休憩 11:45~12:00

◆Session 4 座長：一恩英二（石川県立大学環境科学科） 12:00~13:00

19. ダム湖濁度の鉛直分布の時間的変化について 83

12:00~12:15 高知大学農学部 太田健・杉本亮・松本崇弘・木下彰弘・○紙井泰典
インド工科大学カーラグプール校 Madan K. Jha
NPO 法人環境の杜 石川妙子

20. 降水量変動に伴う田畑からの窒素排出負荷量の推定 89

12:15~12:30 京都大学大学院農学研究科 ○長野峻介・前田滋哉・河地利彦

21. 釧路湿原内の河川・池塘・湧水の水質及び同位体分布特性 91

12:30~12:45 農研機構 農村工学研究所 ○土原健雄・吉本周平・石田聡
皆川裕樹・今泉眞之
和歌山大学システム工学部 井伊博行

22. 深層崩壊地の水質特性 95

12:45~13:00 鹿児島大学農学部砂防学研究室 ○寺本行芳・下川悦郎
鹿児島大学大学院連合農学研究科 ハフィザアクター
東北森林管理局 正留誉恵

◆昼食休憩 13:00~14:00

◆Session 5 座長：竹内潤一郎（京都大学大学院農学研究科） 14:00~15:15

23. 土の毛管障壁機能を利用した雨水ハーベスティングの検討 97

14:00~14:15 新潟大学農学部 ○森井俊広
新潟大学大学院自然科学研究科 松本 智
鳥取大学乾燥地研究センター 井上光弘
鳥取大学大学院農学研究科 藤井 尚
鳥取大学大学院農学研究科 貴堂史子

24. 給水量が制限された水田地域における最適用水配分 103

14:15~14:30 京都大学大学院農学研究科 ○永持達也・前田滋哉・河地利彦

25. Key Issues in Management of Existing Micro-Dams in Ghana 109

14:30~14:45 Faculty of Agriculture, University for Development Studies (UDS), Ghana
Felix Kofi Abagale
Graduate School of Agriculture, Kyoto University
○Koich Unami, Toshihiko Kawachi

26. 宮崎大学農学部の改組について－森林緑地環境科学科の誕生－ 113

14:45~15:00 宮崎大学農学部 ○稲垣仁根

Key Issues in Management of Existing Micro-Dams in Ghana

Faculty of Agriculture, University for Development Studies (UDS), Ghana Felix Kofi Abagale
Graduate School of Agriculture, Kyoto University ○Koichi Unami, Toshihiko Kawachi

1 Introduction

Securing fresh water is a pivotal issue in West African savannas. Most of rural communities are faced with hard access to perennial natural water body, and endeavors are being done in the context of modern water resources development. Water harvesting with micro-dams is a promising option to bridge gaps between natural surface water availability and water demand at community level, and thousands of small reservoirs can be found in West African savannas. In comparison with large dams and with ground water resources, micro-dams have advantages of accessibility from scattered rural communities, less impact on local ecosystems, and multiplicity of purposes. However, there are still disappointing issues in practical management of existing micro-dams. In this work, an overview of such issues is given in the sight of field studies conducted in Tolon/Kumbungu District, Northern Region (NR) of Ghana.

2 NR of Ghana and GbW-IV

The Guinea savanna agro-ecological zone constitutes a strip between the equatorial forest zone and the Sudan savanna zone in West Africa and covers most part of NR of Ghana. The annual rainfall pattern is monomodal with the single rainy season from mid-March to October. The mean annual rainfall concentrating in the rainy season is 1,050 mm at Tamale, the capital of NR (BBC Weather 2007). There is substantially no rain in the dry season from November to mid-March.

The International Institute for Land Reclamation and Improvement (ILRI) provides the standard reference to West African inland valleys (ILRI, 1993). One of the characteristics of land use in NR of Ghana is intensive agricultural production in inland valleys, which comprise well-drained uplands and hydromorphic valley bottoms. Traditionally, slash-and-burn farming system is established on the uplands, while the valley bottoms, which appear as wetlands during rainy seasons, are cultivated for rice production. There is a considerable pool of genetic diversity in crops, enabling robust production against climatic variability, pests, and diseases. Grazing animals such as cattle (*Bos primigenius taurus*), goats (*Capra aegagrus hircus*), and sheep (*Ovis aries*) are commonly seen. The guinea fowl (*Numida meleagris*), which is the poultry indigenous to the Guinea savanna agro-ecological zone, is free-range. Shea tree (*Butyrospermum parkii*) and dawadawa tree (*Parkia biglobosa*) are economically very important.

Bontanga River is one of the tributaries of White Volta and flows through Tolon/Kumbungu District of NR. An inland valley, which is a sub-basin of the catchment basin of Bontanga River, is chosen as the main study area and is referred to as the Gbullung-West inland valley (GbW-IV). Unami et al. (2009) conducted hydraulic studies on GbW-IV. Plane view of the inland valley with ground surface elevation of the valley bottoms and with key components is shown in Fig. 1. The valley bottoms can be identified from QuickBird satellite images as many rice threshing fields are found in them. Feeder roads are embanked across the valley bottoms, and culverts of circular or rectangular cross sections are installed beneath the roads. Bontanga River has no perennial flow in the part forming the downstream boundary of GbW-IV. The soil of the uplands is classified as Dystric Plinthosols while that of the valley bottoms is Dystric Planosols (CERSGIS 2005).

There are 6 micro-dams (Dams 0 through 5) constructed in 1990s across the valley bottoms of GbW-IV, and four of them (Dams 2 through 5) are equipped with concrete spillways. Dam 0 and Dam 1 are rather simple dugouts. Key parameters of the micro-dams such as catchment area (CA), catchment area of valley bottoms (CAoVB), inundation area (IA), inundated rice fields (IRF), dead-storage level (DSL), width B of concrete spillway, full supply water level (FSL), and freeboard (FB), are summarized in Table 1. The surface areas are estimated from Fig. 1. Rural communities are situated in uplands, and most of the residents are subsistence farmers of mostly cereals (maize (*Zea mays*), guinea corn (*Sorghum bicolor*), rice (*Oryza sativa* and *Oryza glaberrima*), etc.), tubers (yam (*Dioscorea* spp.), cassava (*Manihot esculenta*), etc.), and legumes (cowpea (*Vigna unguiculata*), soya bean (*Glycine max*), groundnut (*Arachis hypogaea*), etc.). However, there are few fishermen in Kunkulun, who occupy themselves in fishing in Dam 2.

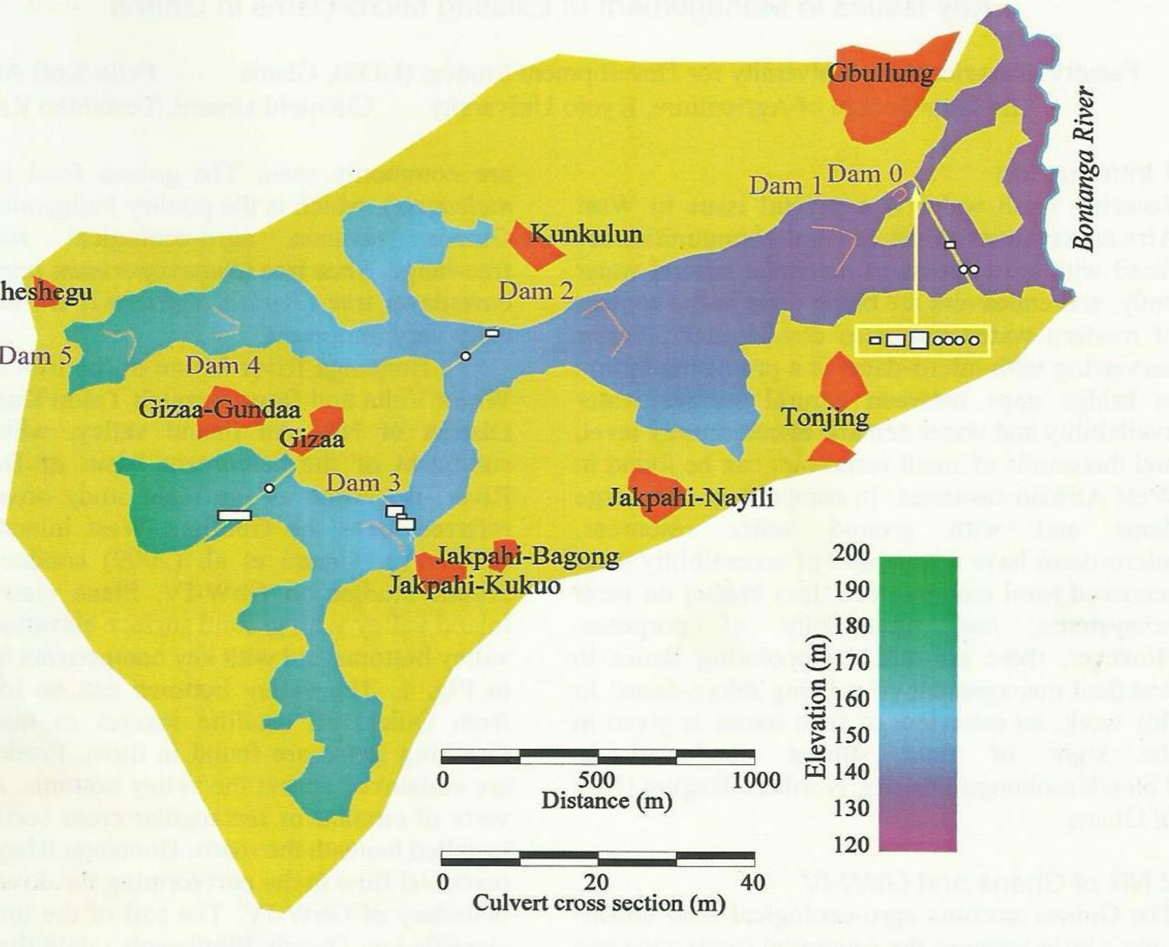

Figure 1. Plain view of GbW-IV

Table 1. Key parameters of micro-dams in GbW-IV

Dam No.	CA (ha)	CAoVB (ha)	IA (ha)	IRF (%)	DSL (m)	*B* (m)	FSL (m)	FB (m)
0	1,779+81=1,860*	522+11=533*	0.9	8.2	EL134.20	No concrete spillway		
1	1,226+553=1,779	375+147=522	9.7	6.6	EL135.20	No concrete spillway		
2	518+123+585=1,226	154+41+180=375	11.0	6.1	EL142.70	24.5	EL144.85	0.65
3	518	154	8.8	7.1	EL156.30	15.0	EL157.60	0.90
4	42+81=123	13+28=41	2.0	3.1	EL160.60	20.2	EL163.15	0.55
5	42	13	2.2	1.7	EL166.40	14.7	EL168.00	0.50

*There is another water course from Dam 1 not flowing into Dam 0.

3 Key issues

3.1 Sacrificing farmlands

Construction of the micro-dams results in creation of backwater areas sacrificing the rice fields in the valley bottoms. As can be seen from Table 1, 34.6 ha (total IA) out of 533 ha (6.5%) of rice fields have been converted into reservoir areas. Due to the multi-purpose usage of the micro-dams, profit emanating from these water storage structures must be more than compensating the loss of farmlands.

3.2 Aquatic habitats

Micro-dams create habitats for fish and other aquatic life and thus job opportunities for inhabitants. Fishing is practiced in Dam 2 as well as in Bontanga River. Diverse fish species including tilapia (*Oreochromis niloticus*), sardine (*Barbus macrops*), and mudfish (*Clarias anguillaris*) exist. Fishing by children can be seen along the Bontanga River, the banks of Dams 1 and 4, as well as the spillway of Dam 3. More minor surface water bodies also become fishing spots after rains. However, concrete spillways disrupt upstream migration of fish. In Dam 5, located upstream end of GbW-IV, both diversity and quantity of fish are minor. This is due not only to the small catchment area of this dam but also to the poor migration routes of fish.

3.3 Relation of Micro-Dams to ground water resoruces

The water stored in the micro-dams is primarily used for domestic purposes in the communities. However, drinking water directly from the micro-dams is not recommended since pollution due to the animals and the waste from the catchment area is serious. The possibility of the water contained in these micro-dams being infected with water-borne diseases such as *dracunculiasis* (guinea worm) is still high as Tolon/Kumbungu District is one of the districts with a high incidence of the disease. Fetching water from the wells that are scattered in the valley bottoms is more hygienic. However, dug wells often dry up in dry season, and water from deeper tube wells is brackish. Fig. 2 depicts water level (blue bullets) and salinity (green builets) in a dug well at 09 28 26 N 001 00 51 W between Tonjing and Dam 1 as well as salinity (red bullets) in a tube well at 09 28 19 N 001 03 25 W between Cheshegu and Dam 5. The dug well dried up from January to May in 2009.

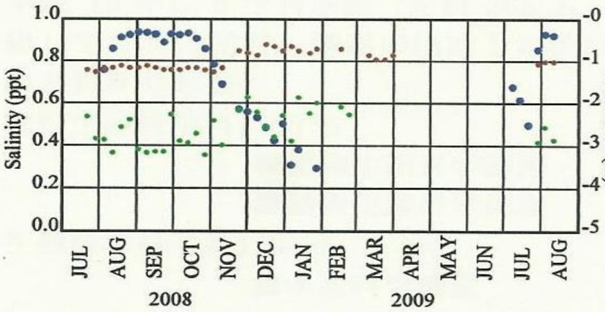

Figure 2. Water level and salinity of wells

3.4 Overtopping and dam breaks

Silting in the reservoir, erosion of the dam wall, and poor design of the spillway or not adhering to design specifications during construction may result in a dam break devastating downstream farmlands as well as feeder roads in the area. With the high rainfall intensity especially in late august and early to mid-September when the valley bottoms appear as wetlands, the running surface water flow exceeds the capacity of the spillways and often overtops the dam walls. Dam 0 has been left breached at least since 2005, as shown in Photo 1. Dam 1 has experienced overtopping of the dam wall in September 2009, and the community members are currently protecting the dam wall from further erosion using sand bags, as shown in Photo 2. The spillway of Dam 3 is also experiencing erosion at one of its sides, as shown in Photo 3. High water overtopped Dam 4 and resulted in the dam break, as shown in Photo 4. Lack of rehabilitation works following dam breaks is a problem.

Photo 1. Breach of Dam 0 used for passage

Photo 2. Protection of overtopped Dam 1 wall

Photo 3. Eroded side of Dam 3 spillway

Photo 4. Break of Dam 4 wall

4 Conclusions

There is still an absolute shortage of fresh water that hinders poverty alleviation in the West African savannas and Northern Ghana in particular. Several key issues have been enumerated to grope for better management of existing micro-dams.

The authors thank Miss Awudu Humu Fadil and Mr. Atindana Owen Amihali, former students of the Faculty of Agriculture, UDS, Ghana, for their support in the field studies.

References

[1] British Broadcasting Corporation (BBC) (2002). BBC Weather, Tamale, Ghana. http://www.bbc.co.uk/weather/world/city_guides/results.shtml?tt=TT000250.

[2] Centre for Remote Sensing and Geographic Information Service (CERSGIS) (2005). FAO soil classification map for SLaM study site in Fihini area. University of Ghana, Legon, Accra.

[3] International Institute for Land Reclamation and Improvement (ILRI) (1993). Inland valleys in West Africa: An agro-ecological characterization of rice-growing environments. ILRI Publication, 52, P. N. Windmeijer and W. Andriesse, eds., 37-44.

[4] Unami, K., T. Kawachi, G. Kranjac-Berisavljevic, F. K. Abagale, S. Maeda, and J. Takeuchi (2009). Case study: Hydraulic modeling of runoff processes in Ghanaian inland valleys, *J. Hydr. Engrg.*, ASCE, 135(7), 539-553.