小規模灌漑の整備に向けた簡易堰の効率的な利用に関する一考察
Efficient use of simple weirs for small-scale irrigation in Zambia

○アレックス　カブウェ*・兵頭　正浩**・緒方　英彦*・佐川　喜裕***・足達　慶尚***
KABWE Alex, HYODO Masahiro, OGATA Hidehiko, SAGAWA Yoshihiro and ADACHI Yoshinao

1. Introduction

Accessing water from the rivers by gravity has become a common method of irrigation among small-scale irrigation schemes in Southern African countries (Malawi, Mozambique and Zambia) (Lautze et al. 2017). In Zambia, the method has been enhanced by incorporating simple weirs to facilitate river diversion for various purposes. This is because small-scale irrigation systems such as simple weirs have proven relatively affordable and adaptable to rural environments with the potential for gravity irrigation. Traditionally, small-scale farmers have relied on rainfall, buckets and scooping methods. This type of irrigation method has affected the expansion of area under small scale irrigation.

There is inadequate information about the efficient usage of simple weirs for irrigation in Zambia despite the technology being popular among small-scale rural farmers. For example, Smith (2014) mentions problems that simple weirs have had such as requiring regular maintenance, damages and leakage, and seasonal re-construction. The re-construction of simple weirs at the onset of each irrigation season has a potential risk to the sustainability and adoption of the technology for irrigation purposes. This paper reports on the results of the simple weir maintenance fieldwork conducted in Zambia to assess the potential causes of weir damage and collapse and establish a mechanism for the efficient use of simple weirs.

2. Target area and methods

Zambia has three (3) distinctive climatic seasons dry and hot (August –November), dry and cool (May-August) and a wet rainy season (November-April). However, the southwest of the country has a semi-arid climate. Zambia's climate is influenced by the high-altitude landscape (1200m ABL). The annual average rainfall varies across the country from 800mm to 1500mm. The wettest areas in Zambia are found in the northern region with rainfall exceeding 1000mm per year **(Fig.1**).

Fig 1: Map of Zambia (northern region) in blue colour.

The data used in this paper was obtained from (Japan International Cooperation Agency (JICA) & Sanyu Consultants INC, 2014) completion report. The quantitative data include stream width dimension, weir length, and upstream depth of water. The field reports, first-hand training, weir users' experiences, observation, and suggestions provided both qualitative and quantitative data.

3. Results and discussion

This paper used both qualitative and quantitative data sets to supplement data that might not have been considered in one data set but found in the other data set during collection. In the initial

*鳥取大学大学院連合農学研究科　The United Graduate School of Agricultural Science, Tottori University
**鳥取大学農学部　Faculty of Agriculture, Tottori University
***三祐コンサルタンツ株式会社　Sanyu consultants
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stages of studying simple weir use for small-scale irrigation both data sets are necessary now and in future studies. An example is given as representative of qualitative and quantitative data, respectively.

Small-scale irrigation schemes have contributed to the transformation of the local livelihoods through household income generation, diversified vegetable production and enhanced household food security. Small-scale gravity-fed irrigation schemes have been popularized in the rural areas of Zambia because of their significant potential. In 2009, technical assistance from the Japan International Cooperation Agency (JICA) has implemented the Technical Community Based Smallholder Irrigation (T-COBSI) with the view to assist small-scale farmers to shift from practicing subsistence irrigated agriculture to market-oriented irrigated agriculture, embrace irrigated agriculture production techniques and promoting simple weir irrigation technology. However, as shown in **Fig. 2**, the main purpose of the visual design is for farmers to be able to construct the weirs themselves, and the spacing of the piles of the simple weirs is not determined. Therefore, it is necessary to consider what parameters should be used to develop the designs for medium-term use.

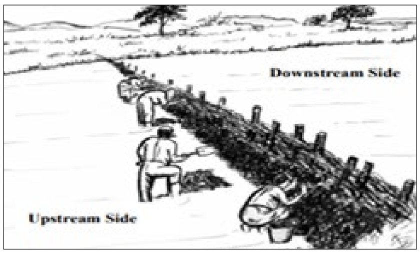

Fig.2. Single line simple weir.

The simple weirs introduced in our country are classified into four types. Each is known as a single-line type, a double-line type, an inclined type and a trigonal type. Each of these types, in turn, has a higher capacity as a weir, but the complexity of the structure makes it more difficult for farmers alone to make them. According to JICA/SANYU (2014), 344 small-scale irrigation schemes (sites) were established between 2009 and 2014. **Table 1** shows a breakdown of these types. As can be seen from the data, the single type accounts for 73% of the total. This is because the single type is structurally the simplest, and because it is intended for rivers with narrower river widths and therefore has lower water pressure. However, for the selection of simple weir types, rough guidelines such as river width are given as quantitative indicators, but no reference is made to river width or riverbed soil quality. Consideration of these factors would lead to a more appropriate type selection.

Table1.Type of weirs (2009-2014)

Type of simple weir	Number
Single line	247
Double line	46
Inclined	33
Trigonal	18

4. Conclusion

Despite the successful implementation of simple weirs in the quest to promote small-scale irrigation in the northern region of Zambia, their efficient use has not been assessed. The problems associated with simple weirs include partial damage/collapsing of the structure within 4-5moths of its construction. This paper envisaged developing a cost-effective and practical method of implementing simple weirs with significance to resist hydraulic pressure an issue that has been established in this study as responsible for damaging and collapsing of simple weirs.

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