CHARACTERISTICS OF WELLS USED IN DIMBA BUCKET IRRIGATION IN MALAWI

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Abstract

Bucket irrigation by smallholder farmers in wetlands dambos in Malawi is an important economic activity and an important source of vegetables for households and cities. Dimba gardening contributes to food security and up to 70% of the household income. A survey was carried out in three districts of Malawi to assess the characteristics of wells used in dimba bucket irrigation in Malawi using watercans between 2000 to 2008. The study was necessitated by government's introduction of treadle pumps. The aim was to investigate whether the dimba wells as currently configured had sufficient water storage volume for treadle pumps.

Results from the survey indicate that majority of the wells were cylindrical in shape with water storage volume of less than 4m^3. Most wells were less than 1.5m in diameter and had a maximum depth of 5m. The water depth in the wells was between 0.2m to 1m. The water storage capacity in the hot dry season for most of the wells were too low to meet irrigation water demands for treadle pumps (6m^{3}per day). There is need to develop new well designs specifically for treadle pumps to meet the 6m³ per day crop irrigation demand. Incorporation of a minimum 20 m² pond to be shared between two adjacent (≥0.1ha) dimba gardens would improve water availability and meet the demand of treadle pumps while at the same time providing water for fish farming.

Keywords: *Dambo wetlands, shallow well design, bucket irrigation, treadle pumps.*

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1.0 Introduction and Literature Review

Malawi is characterised by unimodal rainfall and highly dependent on rain-fed agriculture as the main form of crop production (Malunga, 2009 and MoG, 2010).Coupled with erratic rainfall due to climate change, Malawi is persistently vulnerable to food insecurity. Dimba gardens (size 0.01-0.05 ha) in *dambos* (wetlands) used for winter cultivation are significantly contribute to household food security and income (Chinsinga, 2007). Dimba cultivation offers farmers increased security of crop production, by either supplementing meagre harvests from the rain-fed crop production or generating income from vegetable sales.

Mulwafu (2003) argued in support of dimba cultivation and noted that dimbas presents lasting opportunities for the improvement of living standards of peasant farmers in the country and consequently alleviating rural poverty in the country. The main crops in dimba gardens are a variety of vegetables (tomato, cabbages, onions, mustard and potatoes) and maize which are grown for both home consumption and for income. A study by Wiyo and Kasomekera (1994) in Ntcheu and Dedza districts of Malawi found out that dimba farming contributes up to 70 percent of the household income and hence its continued popularity in these two districts. Over the years, dimba farming has spread to many districts throughout Malawi (e.g Mzimba, Thyolo, Chikhwawa and Lilongwe).

Maintaining year-round vegetable production depends on access to water sources for irrigation purposes during the dry season (Drechsel *et al.*, 2006). Dambos are subject to flooding during rainy season and retain some residual moisture during dry season (Malunga, 2009). In the wake of climate change characterised by increasing dry spells, poorly distributed rainfall and occasional drought, water tables in the dambos in the dry season are declining resulting in moisture stress. As such, farmers resort to digging shallow (open) wells in the dambos in a quest to sustain dry-season cultivation while utilizing water can (bucket) irrigation (Wiyo and Kasomekera, 1994 and Kambewa, 2005).

The dry season in Malawi, when irrigation is a necessity, stretches from April to late November when effective rains begin. The residual moisture from rainfall is often depleted by July. This calls for supplementary irrigation through informal bucket irrigation from dug shallow wells

from July onwards. Availability of groundwater in dambos varies temporally and spatially and consequently water management in dambos is vital for sustainable utilisation (Valeta and Wiyo, 2009). Since water levels in shallow wells in dambos vary with changes in water tables in the dambos, the long dry season is often associated with dry wells.

Seasonal fluctuation of water levels, other than geologic formations of the underlying strata is one of the important factors to consider when choosing a well design (Raghunath, 1983). A water-well has to be designed to get the optimum quantity of water from a given geological formation. Management of wells also greatly determines their lifetime and performance. Poorly constructed and abandoned wells might result in poor quality and groundwater or aquifer pollution (Raghunath, 1983). But plants require adequate and good quality water for proper physiologic and metabolic activity (Valeta and Wiyo, 2009).

The objective of this paper was to assess the characteristics of shallow wells used in dimba bucket (watercans) irrigation in selected districts of Malawi. This was necessitated by government's introduction of treadle pumps. The aim was to investigate whether the dimba shallow wells as currently configured had sufficient water storage volume for treadle pump irrigation given the fact that the shallow wells were originally dug for watercans with small extraction rates.

2.0 Methodology

Well characteristics data was collected in three districts of Malawi (Lilongwe, Dedza and Ntcheu) between the years 2000 to 2008 as part of research activities at Bunda College. Despite the spread in years, dimba wells characteristics do not change much from year to year. These districts were selected because of the proximity to Bunda College and also because these districts are major dimba cultivation areas in Malawi. In Ntcheu, the survey was done in villages surrounding the town of Mlangeni (n=36) while in Dedza, it was done in villages around Mayani

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(N=22) and Bembeke (N=59) Trading Centres. In Lilongwe, it was done in villages of Traditional Authority Chadza area (N=70).

A number of wells selected at random within an area were physically visited and the shape of the well noted. The shape characteristics noted were rectangular, square, circular and odd. Majority of the wells inspected were circular while a few were rectangular. Odd shapes were rare. The size of each well was measured using a measuring tape and an echo sounder was used to measure depth of the well and the depth to the water table. The parameters were measured to the nearest millimeter. Parameters measured were dimensions of the well (length, width or diameter) and depth from the ground to the bottom of the well as well as depth to the water table.

The measurements were done in the dry season between August and October. This time was chosen because water tables are at their lowest and water is scarce while demand is higher in line with the objectives of the study. From the well dimensions, the depth of water was calculated together with storage volume within the well using appropriate mathematical formula for rectangular and cylindrical wells. Means, maximum, minimum and standard deviation of the measured and calculated parameters were calculated using excel spreadsheet for the three areas.

3.0 Results and Discussion

This section summarises the dimensions of different parameters for shallow wells in the study areas. Table 1 and 2 presents the dimensions for dimba wells in Dedza (Bembeke and Mayani respectively). The results indicate that in Bembeke, the depth of shallow wells ranged from 0.27 m to 3 m with an average depth of about 1 m (0.99 m). The depth of water in the wells ranged from 0.25 m to 2.25 m while the average depth of water was 0.75 m. The diameter of wells ranged from 0.94 m to 4 m with an average diameter of 1.36 m. The average volume of a well when full was 4.59 m^3 while that of water in the well at the time of the survey was 3.40 m^3.

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In Mayani, Dedza, the depth of wells ranged from 0.51 m to 5 m with an average depth of 1.44 m. The depth of water in the wells ranged from 0.10 m to 4.54 m while the average depth of water was 0.55 m. The diameter of well ranged from 0.4 m to 4.4 m with an average diameter of 1.26 m. The average volume of the well when full was 5.92 m^3 while that of water in the well at the time of the survey was 4.00 m^3.

Table 3 summarizes the dimensions for the different parameters for shallow wells, used in dimba bucket irrigation in Mlangeni, Ntcheu. Table 3 indicates that the depth of wells ranged from 0.53 m to 9.1m with an average well depth of 1.27 m. The water depth ranged from 0.2m to 1.45m, and diameter ranged from 1m to 3.2m. The mean volume of wells when full was 5.58 m^3 while that of water in the well at the time of the survey was 2.12 m^3. Thus, it was observed that wells in Mayani were deeper (1.36m) as compared to wells in Bembeke (1.26m) and Mlangeni (1.27) and had a larger storage volume. These differences are likely due to differences in the hydrogeology of the three areas.

In Chadza, Lilongwe, parameters for dimba wells were categorized based on season of the year. The cold season comes soon after the rains and covered the months of April to July while the hot dry season covered the period from August to October. These are presented in Table 4. This was done to see variations in water depth across seasons. In the dry season where dimba gardening is practiced, the depth of wells ranged from 1.2m to 4.5m while the depth of water in the well ranged from 0.35m to 1.28m with an average water depth of 0.48 m. The average volume of wells when full was 3.78 m^3 and that of water in the well during the time of the survey was 1.15 m^3. In the cold season, the water table from the ground was 0.46m while it was 0.98m in the hot dry season. The mean water depth was 0.77m and the water storage volume was 2.61m^3. These results indicate that there is wide variation in water tables and storage volumes from the cold season to hot dry season as expected. Water tables in dambo wells start declining as soon as rains stop and recover with the start of the rainy season.

Actual observed water storage capacity in the hot dry season for most of the wells were too low to meet irrigation water demands for treadle pumps (6m^3 per day). Ideal well designs were developed for treadle pumps to meet the targeted 6m³ per day *dimba* crop irrigation demand.

Critical review shows that incorporation of as small as 20 m² pond to be shared between two adjacent (≥0.1ha) *dimbas* would improve water availability and meet the demand of treadle pumps. This would also allow irrigation by motorized diesel pumps while raising fish in the ponds. The irrigation and aquaculture pond/well designs need to be aligned to advocate for such integrated approaches to dimba farming.

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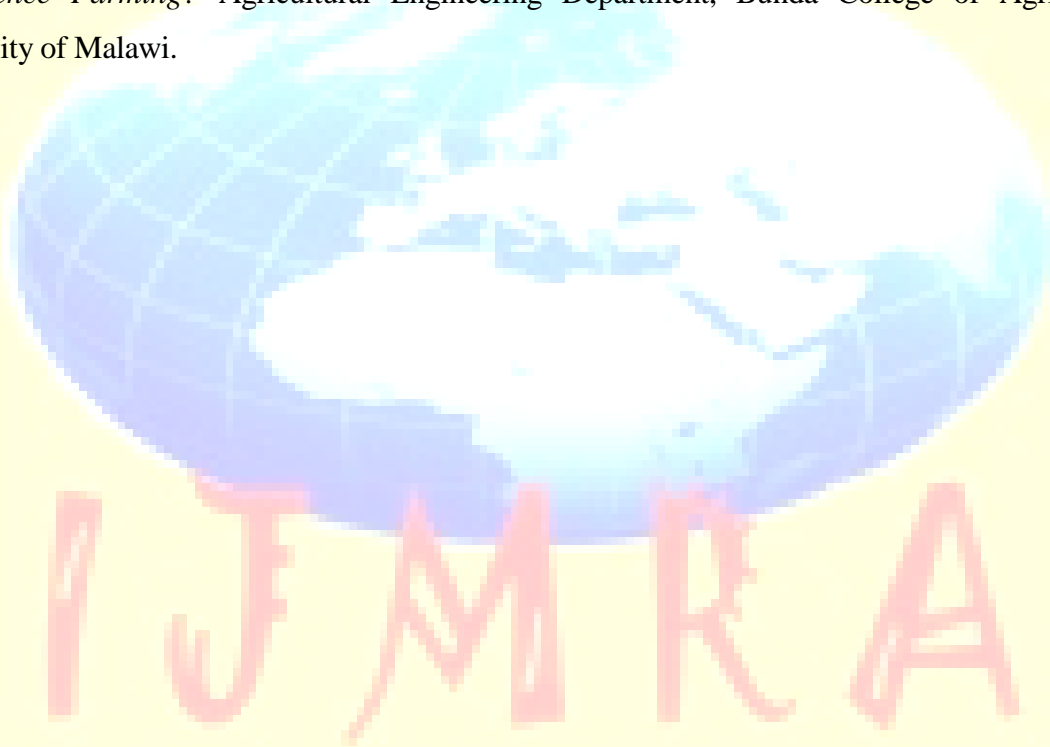
Appendix

List of tables

Table 1: Characteristics of dimba wells in Bembeke, Dedza

Parameter	N	Max	Min	Mean	Std. dev	CV (%)
Length (m)	59	5.0	0.8	2.22	1.0942	0.49
Width (m)	59	4.0	0.4	1.43	0.8504	0.59
Diameter (m)	59	4.0	0.94	1.36	0.5635	0.42
Depth of well (m)	59	3.0	0.27	0.99	0.4962	0.50
Depth of water (m)	59	2.5	0.25	0.75	0.4321	0.57
Volume of well (m^3)	59	60.0	0.19	4.59	10.8947	2.38
Volume of water (m^3)	59	50.0	0.10	3.40	8.9527	2.64

Table 2: Characteristics of dimba wells in Mayani, Dedza

Parameter	N	Max	Min	Mean	Std. Dev	CV (%)
Depth to WT (m)	22	1.85	0.40	0.89	0.420	0.47
Depth of well (m)	22	5.00	0.51	1.44	0.972	0.68
Depth of water (m)	22	4.54	0.10	0.55	0.929	1.70
Diameter of well (m)	22	4.40	0.40	1.26	1.081	0.86
Volume of well (m)	22	76.06	0.088	5.92	16.401	2.77
Volume of water (m)	22	69.06	0.013	4.00	14.69	3.67

Table 3: Characteristics of dimba wells in Mlangeni, Ntcheu

Parameter	N	Max	Min	Mean	Std. Dev	CV (%)
Depth to WT (m)	36	8	0.2	0.73	1.27	1.74
Depth of well (m)	36	9.1	0.53	1.27	1.41	1.11
Depth of water (m)	36	1.45	0.18	0.54	0.34	0.64
Diameter of well (m)	36	3.2	1.0	2.02	0.63	0.31
Volume of well (m^3)	36	73.22	0.42	5.58	11.87	2.13
Volume of water (m^3)	36	8.85	0.16	2.12	2.08	0.99

Table 4: Characteristics of dimba wells in Chadza, Lilongwe, by season

Parameter	Cold Season (July)			Hot dry season (Oct)		
	Mean	Min	Max	Mean	Min	Max
Diameter (m)	1.96±0.43	1.20	4.50	1.96±0.43	1.2	4.5
Well Depth(m)	1.25±0.34	1.10	2.50	1.37±0.34	1.2	2.22
Water Depth(m)	0.77±0.49	0.49	2.10	0.48±0.69	0.35	1.28
Well Volume (m3)	3.99±1.07	1.92	19.13	3.78±1.45	0	29.29
Water Volume (m3)	2.61±1.28	0.87	17.15	1.15±1.89	0	12.72
Water Table (m3)	0.46±0.73	0.48	1.90	0.98±0.45	0.5	2.21

Note: N=70, mean +-standard deviation