UTILIZATION OF SHALLOW AQUIFERS FOR SMALL SCALE IRRIGATION: A CASE STUDY OF AGATU LOCAL GOVERNMENT AREA OF BENUE STATE, NIGERIA

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ABSTRACT

Agatu Local Government Area of Benue State has a floodplain totalling about 25,000 hectares composed of recent alluvial deposits. There are fifteen exploratory wells developed in the area by Benue State Agricultural and Rural Development Authority (BNARDA). This study carried out standard pumping and recovery tests on the wells and determined the yield of each well. The yields were compared with the crop water requirements of selected crops. Four simple methods of tubewell drilling of shallow aquifers were also comparatively evaluated on the basis of cost and related criteria to see which one is most suitable for the area. The values of the well yields ranged from 1.5l/s as the lowest to 5.0 l/s as the highest with a mean of 2.95l/s. Based on the crop water requirements of selected crops, the yield of each tubewell is more than sufficient to adequately irrigate one hectare of land. The cost of drilling a tubewell using the clear water jetting method was found to be 47%, 72% and 77% of the cost of using the rotary rig, the mud washboring and the baildown methods respectively. Therefore, economically the clear water jetting method is hereby recommended as the most suitable for the study area, especially as it suits the geology of the area very well. With encouragement from Governmental and non-governmental organisations in provision of inputs and credit facilities, the rural farmers in the locality can be gainfully employed in irrigated agriculture during the dry season as against the current practices where they do little or nothing.

INTRODUCTION

Agatu Local Government Area of Benue State has a land mass, most of which is culturable (cultivatable) except for few areas covered permanently by perennial water bodies. The water bodies in the area are shown in Fig. 1; with River Benue being the most prominent. The area has a total floodplain of about 25,000 hectares underlain by recent alluvial deposits. The people are pre-dominantly arable farmers and fishermen with their farming activities strictly tied to the rainy season, which spans from April to October of each year. The long spells of drought even during the rainy season in recent times has led to crop failures in many places including the study area. There is therefore the need to utilise available water resources in the area for irrigation so as to make farming an all-year-round occupation thereby increasing crop production and income.

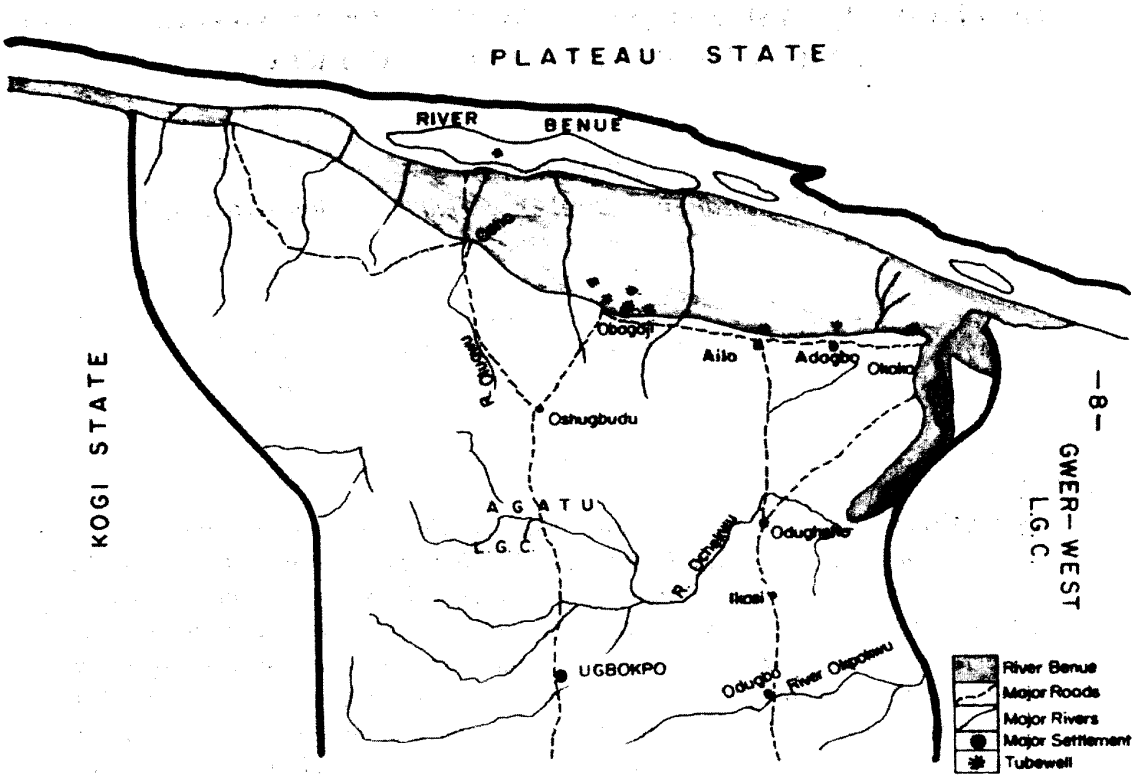

Fig. 1: Map of Study Area showing extent of Floodplan, Rwersystem, Roads and Major Settlements with the Agatu Local Government Area.

An aquifer is a geologic formation that contains sufficient permeable material, which permits storage as well as transmission of water through it under ordinary filed conditions Modi [1]. Water held in geologic voids in aquifer is generally referred to as groundwater. Aquifers may be confined or unconfined. The alluvial deposits of the Benue floodplain form an unconfined aquifer that consists of unconsolidated gravels, silts and clays Moro [2]. Shallow aquifers in this study refer to unconfined aquifers with high water table very near the ground surface usually not deeper than 10-15 metres. Groundwater is a major component of the hydrologic cycle and is used throughout the world for irrigation, municipal and industrial water supply, etc. Hall and Dracup [3]. Basil and Associates [4] reported that the hydrologic characteristics of the alluvium of the area suggest that it would be a good aquifer but that little attention was being given to the utilization of this groundwater resource.

Groundwater abstraction from shallow aquifers of floodplains can be by using the mud washboring method or the clear water jetting method or the baildown method or the small rig (eureka) method. There are 15 exploratory tubewells constructed in the area by Benue State Agricultural and Rural Development Authority (BNARDA). The objectives of this study include:

1. Evaluation of the aquifer yields of these exploratory wells to see whether they can meet the irrigation requirements of crops commonly grown in the area;
2. Determination of the most suitable method of drilling for the study area using comparative cost analysis and related criteria; and
3. Making recommendations that will enhance the utilisation of the groundwater potential of the area for irrigation.

MATERIALS AND METHODS

The fifteen (15) exploratory wells installed by BNARDA and located at different areas in the floodplain as shown in Fig.1 were

used. The yields of the wells were determined by conducting standard pumping and recovery tests.

All the wells in the area were constructed using the baildown method except that of Oweto where the mud washboring method was used. A typical sketch of tubewell installation as used in the study area is shown in Fig.2. To determine the most suitable method for abstracting water from shallow aquifers, four simple methods of rotary rig, bail down, and clear water jetting and mud washboring were comparatively evaluated using the following criteria.

i. Capital cost of equipment
ii. Operating cost
iii. Estimated cost of installing a tubewell
iv. Availability of spare parts
v. Level of technical knowhow required for maintenance
vi. Rate at which tubewells can be drilled
vii. Ease of mobilization/technological transfer
viii. Capability of equipment to deal with local geologic formations
ix. Ease of operation.

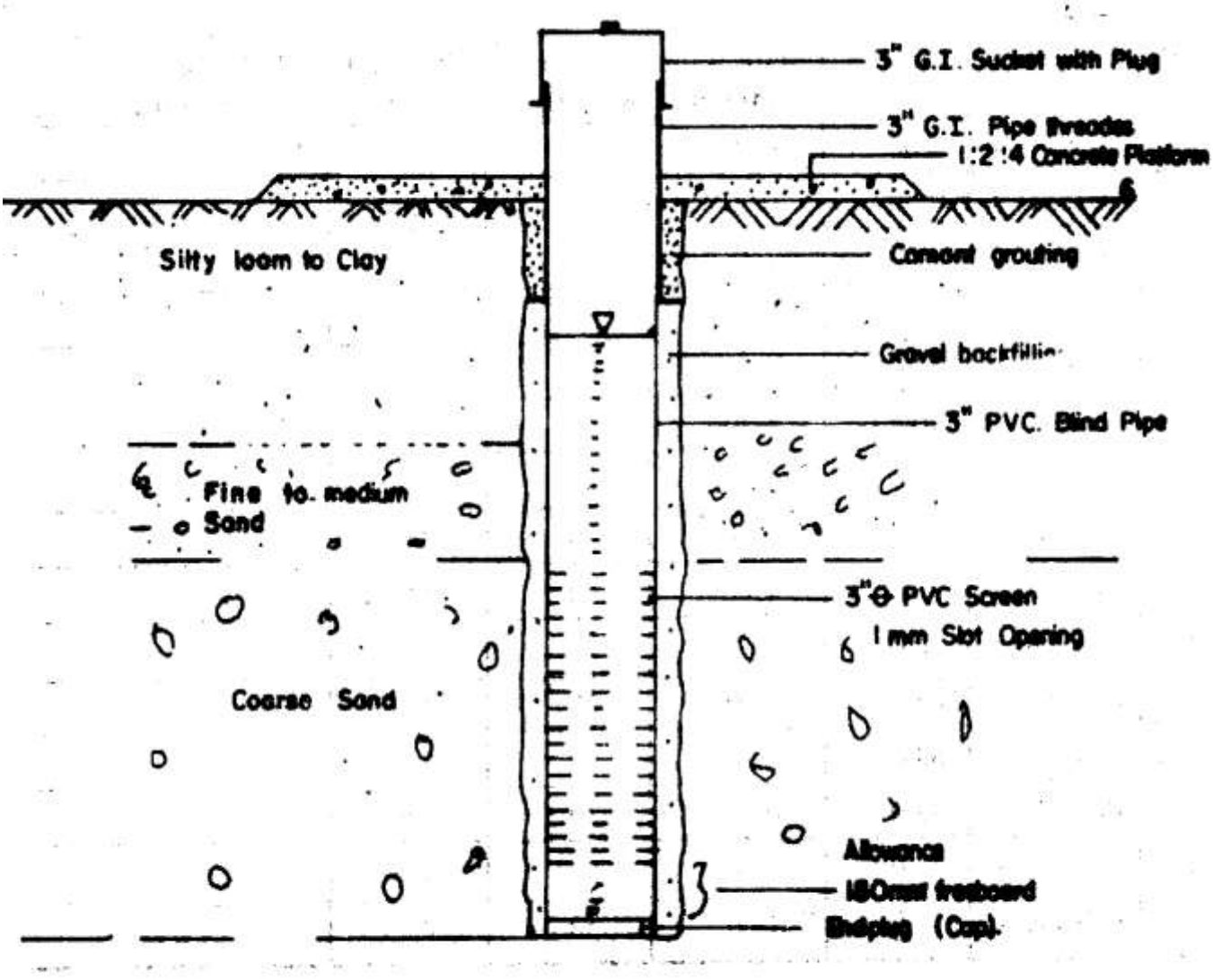

Fig. 2: Typical drawing of Tubewell Installation as used in the project area (Not to Scale).

RESULTS AND DISCUSSIONS

The results of the pumping tests conducted on the wells in the area are shown in Table 1. The results show the well (aquifer) yields to range from 1.5l/s for Ekaida to 5.00 l/s for one of the wells located in Obagaji district, with an average yield of 2.951/s for the study area. Table 2 Moro [2], gives us the estimates of peak irrigation requirements and schedules for crops in the Mu irrigation scheme, Makurdi used for River Benue floodplain. From that information, the volumetric requirement per hectare per second is computed for the different crops and is reflected in Table 3.

The peak irrigation requirement is the highest requirement during the growing season. The smallest yield of 1.5l/s of the well at Ekaida is higher than the highest peak irrigation requirement of 1.24l/*s* /ha for tomatoes. Therefore, even the smallest yield of 1.5l/s can adequately irrigate 1 hectare of land for any of the five crops identified while the highest yield of 5.0l/s can irrigate 4 hectares depending of course on the availability of storage facility in terms of reservoir. Without gigantic storage facilities each well has sufficient yield to irrigate 1 hectare of land and even more.

Table 1: Yields of tube wells in the study area

S/N	Location	Depth (m)	Static water level (m)	Screen length (m)	Yield (I/s) (1/s)	Method used for drillng
1	Utugolugwu	8.00	0.90	2.00	3.50	Baildown
2	Obagaji	7.50	0.70	2.50	4.00	"
3	Obagaji	9.00	1.48	3.70	3.00	"
4	0bagaji	3.80	0.70	2.30	4.00	"
5	Obagaji	4.90	0.76	2.00	2.00	"
6	Oweto	10.50	5.30	5.90	-	Mud washboring
7	Aila	8.60	1.86	3,50	2.30	Baildown
8	Adagbo	7.50	0.95	3.50	2.00	"
9	Okokolo	7.70	1.11	3.50	3.00	"
10	Ocholonya	8.80	2.03	3.50	2.00	"
11	Obagaji	8.00	0.90	2.50	2.00	"
12	Obagaji	8.00	0.90	2.00	5.00	"
13	Ekaida	8.00	0.95	2.30	1.50	"
14	Ochologbu	8.50	1.20	2.50	4.50	"
15	Ocholonya	8.00	1.20	1.50	2.50	"

Table 2: Estimates of peak irrigation requirements and schedules for crops in the Mu irrigation Scheme, Makurdi

	Maize	**Peppers**	**Tomatoes**	**Eggplant**	**Cabbage**
Peak irrigation requirement (mm/day)	10.39	10.26	10.75	10.67	9.35
Net specific discharge (l/s/ha)	1.42	1.32	1.85	1.32	1.85
Total net irrigation requirement (mm)	840	900	960	900	960
Duration of growth (days)	100	110	110	110	80
Irrigation intervals (days)	9	7	5	7	5
Irrigation requirements (m^3)					
(8hrs pumping per day/ha)	40.90	38.00	53.30	38.00	53.30
Gross irrigation requirement (m^3/ha)	58.42	54.30	76.00	54.30	76.00
Planting dates	Nov	20 Nov	10 Nov	20 Nov	10 Nov

SOURCE: (moro, 1989).

At the moment, the farmers cropping a maximum of a hectare per tubewell will be adequately sustained by the average yield of 2.95l/*s*, all losses inclusive. So if we have 14 functioning wells in the area it means it is possible to put at least 14 ha of land into irrigation farming from October to April. For vegetable farming, this is significant. Oamar [5] said that a tubewell yield of 2.0 l/s can irrigate at least 2ha of vegetable crops in Nigeria. Since the farmers of the area are not conversant with irrigation farming, a land holding of between 0.33 and 0.66ha per farmer to start with will engage a least between 21 and 42 farm families in irrigation farming during the dry season. The market prices of these farm products are highest during the dry season. It means that involvement of farmers in the area in irrigation will increase and stabilize their revenue base. Where cash is lacking to purchase agro inputs, provision of credit facilities by governmental and non-governmental organisations (NGOs) can serve as an encouragement to get the farmers in the area into irrigation farming.

The cost of estimates for tubewell construction using four methods mentioned earlier are presented in Table 4; which clearly shows that clear water jetting method is the cheapest. Similar results were obtained by Godowoli [6] for Yobe State and Aponso [7] for Kebbi State. The cost of using clear water jetting method is 46.96%, 71. 96% and 77.4% of the cost of using rotary rig, mud washboring and baildown methods respectively. In other words, the clear water jetting method costs less than half (1/2) the cost of that of rotary rig, barely above two-thirds (2/3) that of the mud washboring and about three quarters (3/4) that of the baildown method to develop a well. It is therefore most economical in terms of cost to develop the 'wells in this floodplain using the clear water jetting method. As shown in Table1, 14 of the 15 wells in the area were drilled by the baildown method and one by the mud washboring method. The extra cost, for using these methods instead of the clear water jetting method by 1995 estimate is put at N62, 102.00 which could have drilled five extra tubewells if the clear water jetting method was used. In addition to the cost consideration, clear water

jetting method is recommended for the development of tubewells to tap the shallow aquifers of the floodplain for the following reasons:

i. The component parts can easily be moved by two people. The rig for example, has to be mounted on a vehicle.
ii. The clear water jetting equipment does not require special skill or training to assemble and operate.
iii. The clear water jetting method is not motorised and therefore does not require spare parts and accessories that need to be imported like other methods.
iv. In suitable sandy soil formation as in the study area, it is fastest method. A tubewell of 12m depth can be drilled within (1/2) hours.

Table 3: Peak Irrigation Requirements of some Crops in Benue floodplain

	Maize	Peppers	Tomatoes	Eggplant	Cabbage
Peak irrigation requirement (mm/day)	10.39	10.26	10.75	10.67	9.35
l/s/ha	1.20	1.19	1.24	1.23	1.08

Table 4: Construction cost per Tubewell using different methods (₦)

S/N	Item	Rotary Rig	Baildown	Mud Washboring	Clear Water jetting
1	Capital Investment	12,570.00	6,517.00	4,514.00	3,762.00
2	Operating Cost	5,790.00	2,450.00	3,350.00	2,833.00
3	Labour	3,450.00	1,300.00	3,750.00	3,125.00
4	Over-head	2,222.00	2,222.00	2,222.00	2,222.00
5	Materials	5,565.00	5,480.00	5,480.00	1,958.00
	Approximate Totals	₦29,597.00	₦ 17,949.00	₦ 19,316.00	₦ 13,900.00

Oamar [5] had advised that clear jetting method, which is the cheapest and the simplest drilling method should be used for drilling washbores in Fadamas in Nigeria for small scale irrigation development with other methods being employed only where clear water jetting is not feasible.

It is necessary to note that the only tubewell drilled by the mud washboring method in the area did not perform well. It is only when the clear water jetting method is used in the area and evaluated that we can really ascertain whether all the benefits of the method are derivable in the area.

CONCLUSION

The well yields of the tubewells in the study area sufficient to adequately irrigate one hectare per tubewell. Because the farmers in the area are not familiar with irrigated agriculture, we recommend a land holding of between 0.33 ha and 0.66ha per farmer especially for

vegetable farming that requires intensive attention. We also recommend the provision of credit facilities as incentives for the people to start to engage in irrigation farming during their hitherto unemployed to underemployed dry season.

The finding that the clear water jetting method is the most cost effective method for drilling tubewells in the area confirms with earlier findings in other places. The use of other methods other than the clear water jetting method for the existing tube wells had cost an extra of ₦62,102.00. We therefore strongly recommend the use of clear water jetting method for future development of tubewells in the area.

REFERENCES

[1] Modi, N.P. Irrigation, *Water Resources and Water Power Engineering* 2nd Edition Standard Book House, New Delhi, 1990, pp. 154-221.

[2] Moro, M.O.P. Water Requirements and Scheduling of Mu Minor Irrigation Scheme, Makurdi, Unpublished HND project, National Resources Institute, Kaduna, Nigeria, 88p, 1989.

[3] Hall, A.W. and J.A. Dracup, *Water Resources Systems Engineering*, T.M.H. Edition, Tate McGraw Hill, New Delhi . 329p, 1970.

[4] Basil and Associates. A Predrilling Hydrological Investigation Benue Valley Study Area XVI, Vol. 1, 1979.

[5] Oamar, U. National Fadama Development Project (NFDP) and Fadama Phase Two: A Review. Federal; Agricultural Coordinating Unit, Sheda, Abuja, 1994.

[6] Godwoli, A.A. Yobe State ADP. Detailed Project Proposal for National Fadama Development Project (National Fadama Facility), 1993.

[7] Aponso, M.C.D. V., The Management of Tubewell Drilling Contract. Paper presented at Federal Agricultural Coordination Unit Training Workshop, Argungu, Kebbi State, Nigeria, 14- 31st March, 1994.