

ECONOMIC RESEARCH BUREAU  
UNIVERSITY COLLEGE, DAR ES SALAAM

E.R.B.Paper 69.17

RURAL WATER SUPPLY AND DEVELOPMENT: A COMPARISON OF NINE VILLAGES IN  
TANZANIA

by

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RURAL WATER SUPPLY AND DEVELOPMENT:

A COMPARISON OF NINE VILLAGES IN TANZANIA\*

Water supply has always been looked upon as a key factor in development, especially of the rural areas. The First Tanzanian Five-Year Plan of 1964-69 allocated almost nine percent of the total anticipated Central Government investments for urban and rural water supply, with almost half of these expenditures budgeted for rural water supply. In the Second Five-Year Plan of 1969-74 these proportions are expected to remain about the same, but the absolute magnitude of anticipated expenditures will more than double those proposed in the first plan. The following table indicates anticipated investment expenditures in the two Plans:

Planned Investment Expenditures	First Plan 1964-69		Second Plan 1969-74	
	Amount	Percentage	Amount	Percentage
Central Government (Total investment)	Sh.1,440,000,000	100%	Sh.3,055,000,000	100%
Rural Water Supply (Development expenditures only)	30,000,000	2.1%	73,000,000	2.4%
Rural Water Supply (Total expenditures)	58,800,000	4.1%	114,600,000	3.8%
Urban Water Supply (Total expenditures)	66,960,000	4.6%	156,500,000	5.1%
All Water Supply	125,760,000	8.7%	271,100,000	8.9%

In an attempt to more closely integrate the planning and implementation of Tanzania's rural water supplies into its agriculturally-based rural areas, responsibility for water development was transferred back to the Ministry of Agriculture, Food, and Co-operatives in March of this year.

\*This is a slightly modified version of a paper prepared for the East African Agricultural Economics Society Conference, held at the University College, Nairobi, in June, 1969.

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Several factors have led to the need for greater understanding of the impact of water supply projects upon the areas in which they are placed. These factors include (1) the recent advent of the Regional Development Fund which allocates a fixed sum of money to each Region for locally planned development projects; (2) the enlarged programme of rural water supply over the last several years as a result of several Swedish aid programmes, and (3) the increasing importance of the Regional Development Committees in setting out local development priorities.

As part of a study into the impact of rural water supplies upon the development of the rural areas of Tanzania, the Economic Research Bureau of the University College, Dar es Salaam, currently is carrying out field investigations in numerous Districts throughout the country. The overall objective of the study is to formulate guidelines that will aid Regional Development Committees in the selection of proposed village water supply projects having the greatest development potential. Although field investigations are still in progress and nothing as yet can be said about the final guidelines, some preliminary observations are available for a few select villages concerning water usage, water-related activities, and attitudes towards modernization.

It must be pointed out that the observations presented in this paper must be considered tentative, since they are based almost exclusively on information reported by villagers themselves. Verification of these observations is in progress but is not yet completed.

#### Method of Data Collection.

Villages are selected on the basis of several criteria involving their present and future water supply, their population, and their representativeness to the water supply situation of the country as a whole. In general a selected village is investigated by three or four University College students who spend about one week on the site. Approximately 15% to 30% of the heads of households in the village are chosen at random and then interviewed. The questions in these household interviews are asked in an open-ended manner, with the student checking off the villager's reply on a pre-coded answer list. All questions are asked in Swahili for uniformity of presentation. Along with additional information collected from village and district officials and from various government files, this information forms the bulk of the data used in the study. Follow-up visits are planned for most villages in order to determine changes over time, but to date only initial visits have been carried out. The data presented in this paper was collected during the months of March to May, 1969.

This paper will present observations from nine villages located in three Districts of Tanzania -- Pare, Kilimanjaro and Morogoro.<sup>1</sup> Three villages are located in Pare District at the eastern base of the North Pare Mountains; four are located in Kilimanjaro District on the lower southern reaches of Mt. Kilimanjaro, and two are found in Morogoro District on the lower western slopes of the Uluguru Mountains. Thus, all three areas of investigations are similar in their proximity to a major mountain range although none are able to practice irrigation agriculture to any but an insignificant degree. The following is a summary description of each area.

#### Pare District Study Area.

The area is at the base of the eastern side of the North Pare Mountains in an area where agricultural crops and cattle raising are equal in importance. For the most part, a shortage of water is the major problem since most of the inhabitants must walk over two miles for their water supply. The area is ten miles off the main Tanga-Moshi Road and transport to the villages, which is limited to a weekly pick-up truck, is very poor. The three villages are Kwakoa, Nyata and Ngulu. Kwakoa and Nyata have the most severe water problems, although the Water Development and Irrigation Division (W.D. & I.D.) of the Ministry of Agriculture, Food and Co-operatives completed a water supply pipeline with common domestic water points in Kwakoa shortly after the completion of the initial investigation. Neither Nyata nor Ngulu have an improved water supply and must rely on traditional sources, such as streams and water holes.

#### Kilimanjaro District Study Area.

This area straddles the Moshi-Voi Road and is located approximately half way between Moshi and Himo. The villages are on the drier lower slopes of Mt. Kilimanjaro and, thus, exhibit more of the characteristics of the plains than of the coffee and banana areas higher up the mountain. In all four villages, agricultural crops predominate with cattle raising relegated to a minor secondary importance. The four villages are Mdawi, Msaranga, Pumwani-Nanga and Mbuyuni. Pumwani-Nanga has no improved water supply, although it is adjacent to Mbuyuni village, which possesses a water supply pipeline having common domestic water points every one-half mile which was built by W.D. & I.D. in 1962. During the initial investigation, Mdawi village had only a single domestic water point, while adjacent Msaranga village had no improved supply at all. W.D. & I.D. at that time was in the process of completing a pipeline with common domestic points to supply the two villages with additional water. Transport is inexpensive and easily available to the nearby cities of Moshi and Arusha.

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<sup>1</sup> Additional investigations also have been conducted, or at present are in progress, in Handeni, Rufiji, Dodoma and Singida Districts.

### Morogoro District Study Area.

Located twelve miles west of Morogoro near the main Morogoro-Iringa Road, the two villages of Mlali and Kipera form the third study area. These villages are on the lower slopes of the western side of the Uluguru Mountains. Except for a few goats, there are no livestock in the study area, with the result that the agricultural system is based exclusively on crop production. Both villages are within 0.5 mile of the perennial Mlali River, so that both have a reliable source of water, although neither village has an improved water supply system. At the time of investigation, W.D. & I.D. was completing the construction of a water pipeline with common domestic water points in Mlali village. It has plans to extend the Mlali pipeline two miles to Kipera village during 1970. Transport is available throughout the year to Morogoro. Of all the villages included in this study, Kipera has shown the fastest growth rate in recent years.

Thus, there are three distinct types of water supply situations found in the nine villages (at the time of investigation). The first type, villages which do not possess an improved water supply system, includes Nyata, Ngulu, Pumwani-Nanga, and Kipera villages. The second type, villages which do not have an improved water supply system but are in the process of building one, includes Kwakoa, Msaranga, and Mlali villages. The third type, villages which have an existing water supply system, includes only Mbuyuni village. Mdawi village overlaps types two and three, in that even though the village has an improved water supply, in the form of a single domestic water point, work is under way to extend and improve it. In the context of this paper, an improved village water supply refers to water which is brought into a village by pipeline from some outside location and is then made available to the villagers at one or more outside water taps, commonly called domestic water points.

### Water Usage

Without exception, a majority of households in each of the nine villages reported that cooking is the activity that consumes the most amount of all the water used at the house. The next greatest use of water varies between Districts. The Pare villages of Kwakoa, Nyata and Ngulu reported that washing utensils and bathing babies are second major activities, while the Kilimanjaro villages of Mdawi, Msaranga, Pumwani-Nanga and Mbuyuni claimed washing utensils and watering animals are next in usage. Mlali and Kipera villages in Morogoro District reported that bathing adults and children and washing utensils are second in importance. Further inquiries into the use of water at the house showed that only three activities -- drinking, cooking and washing utensils -- are carried out on a daily basis in all nine villages. Other activities, such as bathing babies, bathing adults and children, washing clothes, housebuilding, and watering animals, appeared to be related to the availability of and distance to the nearest source of water. Table 1, shows the incidence of water-related activities occurring among 50% or more of the households in each of the villages.

Table 1. Incidence of Water-Related Activities Carrying at the House.

D = Activity occurs daily; I = Activity occurs irregularly;  
No = Activity does not occur.

	Kw	Ny	Ng	Md	Ms	PN	Mb	ML	Kip
Drinking	D	D	D	D	D	D	D	D	D
Cooking	D	D	D	D	D	D	D	D	D
Washing Utensils	D	D	D	D	D	D	D	D	D
Bathe Babies	D	D	D	I	D	D	D	D	I
Bathing adults and Children	D	I	No	I	I	D	D	D	D
Housebuilding	No	No	No	I	I	I	I	I	I
Animals	No	No	No	I	I	I	No	No	No
Irrigation	No	No	No	No	No	No	No	No	No

### Water Carrying

Water carrying is definitely considered woman's task in all of these villages. A majority of households in each village reported that either women alone or women and children together are the regular water carriers. In most cases this majority exceeded 80% of the interviewed households. An overall total of 44% of the households did state that men sometimes carry water, but this proportion dropped to 17% for households where men carry water at least once per week.

Table. Water Carrying Within the Household.

	Kw	Ny	Ng	Md	Ms	PN	Mb	ML	Kip
No. of households interviewed	21	9	25	16	8	9	18	33	28
No. of households in which men carry water	7	6	15	7	6	8	9	8	7
No. of households in which men carry water at least once per week	1	1	0	3	6	5	4	5	3
No. of households in which women and/or children usually carry water	20	9	24	15	8	9	15	29	24

The villages of Nyata, Ngulu, Msaranga, Pumwani-Nanga and Mbuyuni reported that men do carry water in at least 50% of the households; however, only Msaranga and Pumwani-Nanga indicated that a majority of the households have men who carry water at least once per week.

In this and in all subsequent Tables, the village names will be abbreviated as follows: Kw = Kwakoo, Ny = Nyata, Ng = Ngulu; Md = Mdawi, Ms = Msaranga, PN = Pumwani-Nanga, Mb = Mbuyuni; ML = MLali, Kip = Kipera



Time and Distance in Water Carrying

Great variations in distance to water and time spent carrying water exist between the Districts, and to a lesser extent between villages within a District. Based upon the replies of the villagers, the one-way distance between the house and the source of water varies from 0.5 mile to 2.9 miles, while the one-way time required in fetching water varies between 20 minutes and almost two hours. Table 4 shows values of distance, time, daily trips, and daily debes used on the average in each household. These figures are corrected for seasonal variations in water use in order to show daily averages for a typical year.

Table 4. Distance, Time, Daily Trips, and Daily Quantities of Water.

Household Averages	Kw	Ny	Ng	Md	Ms	PN	Mb	ML	Kip
One-way distance to water (miles)	2.9	2.8	1.0	0.6	1.2	1.3	0.5	0.7	0.7
One-way walking time to water (minutes)	112	109	43	20	42	38	26	25	20
No. of daily adult trips to water	1.9	2.5	2.3	2.3	3.6	3.1	2.7	3.5	4.1
Total daily adult time spent carrying water (hours)	7.1	9.1	3.3	1.5	5.0	3.9	2.3	2.9	2.7
No. of daily child trips for water	1.2	0.5	0.8	2.0	2.4	1.8	1.2	0.5	0.3
Total daily child time spent in carrying water (hours)	4.5	1.8	1.1	1.3	3.4	2.3	1.0	0.4	0.2
Total daily debes of water consumed at the house	1.7	2.2	2.3	3.0	4.6	4.4	3.1	3.6	3.3

Comparisons between Districts may not be valid for Table 4 because of the possible variations in average size of households. Nevertheless, within a given District, rough comparisons between households can be made. For example, the total number of adult hours spent carrying water in Ngulu village is 3.3 hours per household per day, while in Nyata village it is a staggering 9.1 hours per household per day.

Population, Distance, and Per Capita Consumption of Water

By determining water consumption on a per capita basis, comparisons between both villages and Districts can be made. Table 5 illustrates average water consumption based upon average household size.<sup>4</sup>

<sup>4</sup> No attempt was made to differentiate between the consumption by adults, children, or infants.



Table 5. Per Capita Consumption of Water Used at the Household.

	Kw	Ny	Ng	Md	Ms	PN	Mb	ML	Kip
Total households in village	73	44	103	90	37	50	74	172	92
Population per household	7.3	6.7	7.4	5.6	8.0	6.6	5.8	4.4	4.0
Household water consumption in gal/cap/day	0.9	1.3	1.2	2.1	2.3	2.7	2.1	3.3	3.3

It can be seen from the above table that daily water consumption in the Pare villages was lowest, just over one gallon per capita that in the Morogoro villages highest at 3.3 gallons per capita, while the Kilimanjaro villages were in between at 2 to 3 gallons per capita. The most surprising fact is the striking similarity of per capita water consumption between villages within a given District, despite the differences of distance, reliability, and quality. The graphical presentation of per capita daily consumption of water versus average distance to water, shown in Figure 1, illustrates the disparities of distance that occur between villages in Pare and Kilimanjaro Districts. As illustrated by the graph, Ngulu village in Pare District is only one-third the distance from water as its sister villages of Kwakoa and Nyata, yet it uses no more water at the household than the other two.

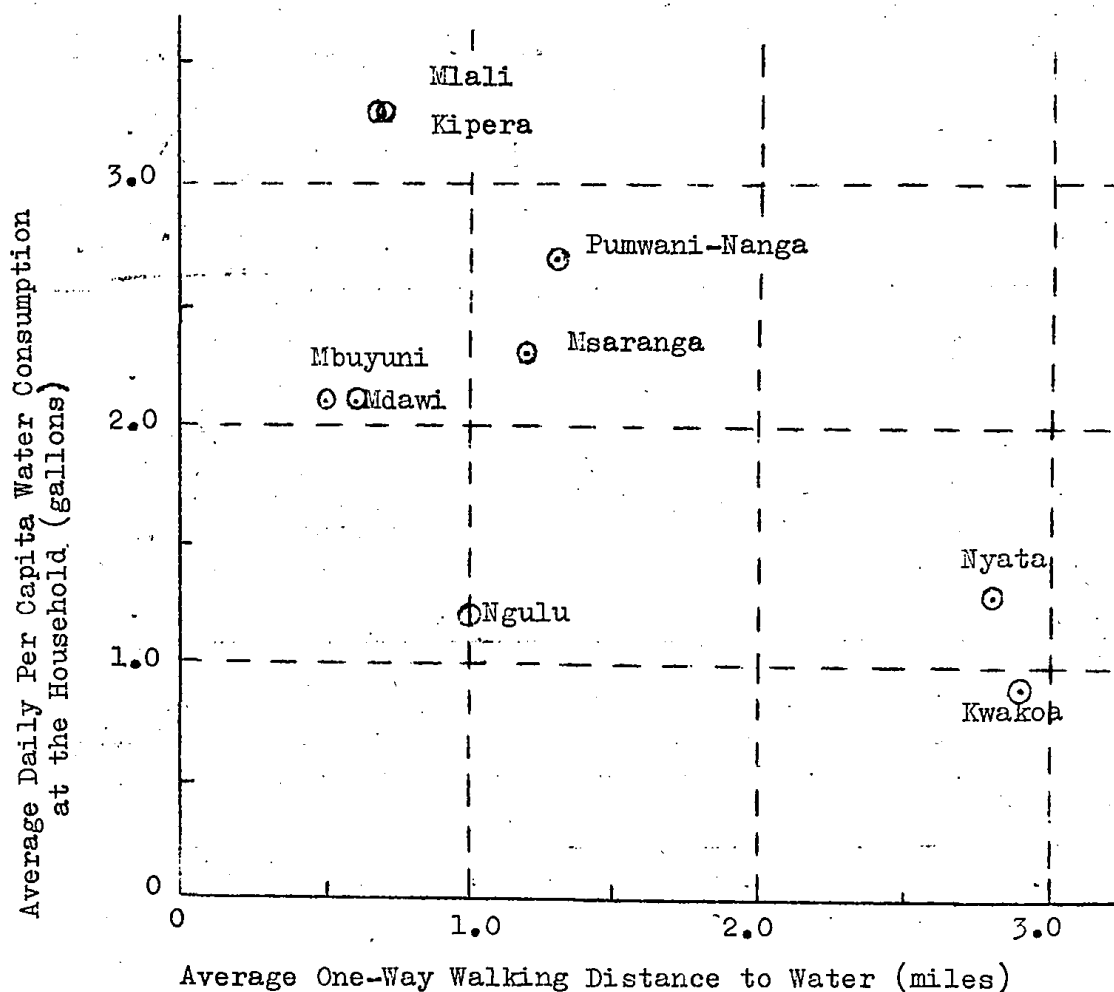


Figure 1. Consumption-Distance Relationships Between Villages.

The reliability, or permanence, of the water source previously was shown in Table 3. Half of the households in Msaranga village claimed their water source was permanent and half reported it seasonal, yet the per capita consumption figures for Msaranga fall just on the average for the other Kilimanjaro villages.

Local perception of water quality also varied. Both Kwakoa and Ngulu reported their water source as good quality, while Nyata split its replies between good and bad quality. All of the Kilimanjaro villages reported good water quality with the exception of Msaranga, which unanimously voted its water of bad quality. Both Morogoro villages claimed their water was of bad quality also. Furthermore, the meaning of the term "bad quality" varied between Districts. Households which reported their water quality as bad in both Kilimanjaro and Morogoro Districts generally explained that their water was dirty, while in Pare District the main explanations included (1) dirty, (2) diseased, and (3) polluted by animals.

No satisfactory answer has appeared in this preliminary analysis as to the reason for the similarity of per capita water consumption between villages within given Districts. The similarity may be only coincidental, or the data possibly may be erroneous, or there may be an unstated, yet controlling, quality of water that households in a given area normally use despite intervillage differences in distance and water quality. This question will be studied further in subsequent field investigations in other Districts.

It is worthwhile to compare these figures of per capita daily water consumption with the W.D. & I.D. design figure of 10 gallons per capita per day. Normally, new W.D. & I.D. projects are designed to provide 10 gallons of water per day to each person presently living within the service area of the project and to have a 100% reserve capacity to allow for a doubling of population over a ten year period.

There is an improved water supply in both Mdawi and Mbuyuni villages. At the time of investigation, Mdawi had only a single domestic water point at a storage tank, but Mbuyuni had a complete series of domestic water points approximately every one-half mile along a pipeline that was completed in 1962. Both Mdawi and Mbuyuni reported a water consumption of only 2.1 gallons per capita per day, which is lower than four other study villages, none of which have (or had) domestic water points and piped water, and none of which have closer average distances to water than Mdawi or Msaranga. Low average daily consumption figures of only 3 gallons per capita for villages with an improved water supply have been observed by other individuals in various parts of Tanzania. These low consumption figures will be investigated more thoroughly in the future at a number of new villages where there are plans to install water meters at the outlet of the village water storage tank.

Productivity of Water Carrying Time

A final set of calculations can be utilized to show the average productivity of water carrying time in the various villages. For this purpose it was assumed that children carry one gallon per trip, while adults carry the remainder of the water. The average of one gallon per child-trip was not verified by actual measurements, and in all probability this average should be somewhat higher for some of the shorter distances found in the Kilimanjaro and Morogoro villages where children occasionally used galvanized steel buckets to carry water. Nevertheless, the results can be considered indicative of actual conditions since the water allocated to adult-carrying, when divided by the number of reported adult trips, varied less than 30% from the capacity of the standard 4-gallon debe, as shown in Table 6.

Table 6. Productivity of Water Carrying Time.

	Kw	Ny	Ng	Md	Ms	PN	Mb	MI	Kip
Adults: gallons per trip	2.9	3.3	3.7	4.3	4.4	5.1	4.1	4.0	3.1
Adults: gallons per hour of walking time	0.8	0.9	2.5	6.7	3.2	4.0	4.9	4.8	4.8
Children: gallons per hour of walking time	0.3	0.3	0.7	1.5	0.7	0.8	1.2	1.2	1.5

The productivity of both adult and children water carrying in Table 6 was calculated by dividing the product of trips per day and gallons per trip by the number of hours spent carrying water per day. This table shows the wide differences in the water carrying productivity of neighbouring villages within Pare and Kilimanjaro Districts.

It has been suggested for certain Kenyan villages that development depends more upon increasing the labour inputs of women than of men, but the difficulty is that the increase is limited by the already high demands upon female labour.<sup>5</sup> Certainly this is true in the case of water carrying in the nine villages included in this paper, since upwards of 85 to 90 per cent of the total time spent carrying water is that of women and/or children. Table 4 showed the large number of hours spent carrying water in each household. Those villages that are distant from

<sup>5</sup>Jane Wills, "A Study of the Time Allocation by Rural Women and Their Place in Decision-Making: Preliminary Findings from Embu District", Faculty of Agriculture, Makerere University College, R.D.R. 44 (1968)(first draft).

water, such as Kwakoa, Nyata, and Msaranga, daily spend from 5 to 9 hours per household carrying water. It can easily be seen that the provision of an improved water supply into these villages could lead to significant time savings for the water carriers, who happen to be the women. The key question for development purposes is whether such time savings would be put to productive use by the people most directly affected.

### Time Usage on Village Activities

Among the adult men in the villages agricultural activities predominate, as a majority in all villages reported shamba farming work as the activity on which adult men spend the most time. This activity totaled 74% of all replies. Cattle tending was second overall with 8.2% of all replies, most of which came from the three Pare villages. Third in usage was paid employment at 7.3%, mainly from Mdawi and Kipera villages. When asked what would the adult men do if more time was available, almost all of the villages reported heavily in favor of the agricultural activities of shamba work, cattle tending, or fishing, for a total of 69% of the replies. Mlali village, however, reported less than half of its adult men would spend any extra time on these agricultural activities. Six of the fifteen non-agricultural replies in Mlali were in favor of paid employment. In the overall totals for all villages, housebuilding was the second most preferred activity with 7.3% and paid employment was third with 6.1%.

The married women illustrated a more divergent set of answers to time usage. Similar to the men, shamba work occupied the most time of a majority of women, totalling 73% of the replies, with water carrying in second place with 10.6%. Shamba work did not dominate the time of a majority of women in all villages, however. In Pare District, Kwakoa village gave only half its replies to shamba work while Nyata gave even less. In both villages water carrying was a major activity; in Nyata it was the principal time consuming activity of more than half the women.

When asked what would the married women do if they had more time available to them, shamba work received only 43% of the replies overall. A total of 45% preferred to spend their extra time on domestic duties such as cooking, washing clothes, gathering firewood, carrying water, caring for babies, etc. Less than 7% replied they would spend their extra time on activities other than shamba work or domestic duties.

Very few men or women -- less than 1% in both cases -- replied that they would prefer to spend their extra time at adult education classes. This may be partly the result of few available opportunities to attend such classes, since few villages were fortunate enough to have the requisite government officials resident for more than a couple of months per year. Only Mlali and Kwakoa villages, for example, offered a regular programme of adult literacy classes within the past year, and these were available for only a few months. Occasionally, villagers were able to attend classes or demonstrations held in nearby villages. A rough indication of the educational opportunities available to adults in the study villages is shown in Table 7, which is based upon representatives of households attending a given class one or more times within the past year.

Table 7. Adult Attendance at Classes, Lectures and Demonstrations.

1 = at least 25% of all households attended one or more times in the past year.

2 = at least 50% of all households attended one or more times in the past year.

	Kw	Ny	Ng	Md	Ms	PN	Mb	MI	Kip
Adult literacy classes attended by heads of households	1	1						1	
Adult literacy classes attended by others in household	1	2	1		1		1		
Public health lectures attended by heads of households	1	1	1		1				
Public health lectures attended by others in household	1				1				
Cooking classes	1				2			1	
Baby care classes	1		1		1				
Agricultural demonstrations attended by heads of households	2		2	1	2				
Agricultural demonstrations attended by others in household	2		1		1				

The grid in Table 7 shows attendance by households in the various adult education activities over the past year. Kwakoa reported at least a 25% participation in all activities, while Msaranga also claimed at least 25% attendance in all activities except adult literacy classes by head of households.

Despite the relatively low preference for adult education activities (when compared to alternative activities), all villages overwhelmingly favor an increase in the number of available classes, lectures, and demonstrations. Favorable replies to this question exceeded 90% of the total households in most villages. Except for Pumwani-Nanga, all villages reported agricultural demonstrations to be the most desired activity.

Water Use in Small Cottage Industries

Small cottage industries are scattered unevenly the three areas, as shown in Table 8. Brickmaking occurs in Mdawi and Mbuyuni villages of Kilimanjaro District and in Morogoro villages, but not at all in the Pare villages. Actually, these four villages which report some brickmaking are the closest to water -- all less than 0.5 miles average distance. In all, there are a total of six brickmaking holds, which use a weekly average of 65 to 75 gallons per household for this purpose. Only the two Morogoro households reported that they pay for water.

Table 8. Water Based Cottage Industries.

	Kw	Ny	Ng	Md	Ms	PN	Mb	ML	Kip
Number of households interviewed	21	9	25	16	8	9	18	33	28
Brickmaking				2			1	1	
Pombe brewing				3	3	5	7	6	3
Coffee Pulping	6		6	1	1				
Other			1	3	1		3	2	5

Pombe (local beer) brewing is carried out in all villages except Nyata village in Pare District. This activity does not seem to be related strongly to distance from water supply, since 23% of the Pare households claimed that they brew pombe while only 15% of the Morogoro households reported the same. The Kilimanjaro households reported a 35% participation in pombe brewing. Although most households claimed that pombe was brewed only at rare intervals (thereby avoiding conflicts with the licensing regulations), the adjacent Kilimanjaro villages of Mdawi and Msaranga reported an average household water use of 28 gallons per week for the six households that brew pombe. Only one household, in Mlali village, stated that it paid for water.

Coffee pulping was almost non-existent, as only one household in each of Ngulu, Mdawi, and Msaranga reported such activity. Only the Msaranga household reported a significant water use - somewhat over 50 gallons per week. None of the three households paid for water.

Other water using activities were limited mainly to washing and preparing vegetables for the market.

Table 7. Adult A

1 = at least 25% asked what was the best way to encourage these the past ye industries, a third of the villagers favored  
 2 = at least water to the village, 18% suggested that training the past to the villagers, and 16% replied that materials  
 ment should be provided to the villagers. A total  
 the respondents did not know of a best way or did  
 ve it was possible to encourage cottage industries.  
 Adult literates, including, Nyata, Mdawi, Msaranga, Pumwani-Nanga,  
 attended by Kipera, favored supplying water as the best method.  
 households in Kwakoa preferred the providing of materials, while  
 Mbuyuni favored training for villages. The households  
 in Ngulu gave equal emphasis to materials and training.

Employment and Technical Training Resulting from water Projects

A number of the villages either had a completed water project or at the time of the field investigations were building one. Completed projects existed in Mdawi and Mbuyuni villages, while water projects were under construction in Kwakoa, Mdawi, and Mlali villages.

In reply to the question which asked whether anyone worked or was working on the water project, only Kwakoa village showed a significant participation rate, as two thirds of the households reported that someone was working on the project -- all but one of them as labourers. Mlali village reported that individuals from only two households had worked on the project, while households in Mdawi and Mbuyuni villages did not report any participation at all. Of the fourteen households in Kwakoa village that claimed some<sup>one</sup> worked on the project, six replied that these individuals received special training for their work -- four of them as labourers, one as a mason, and one as a cook. No other villages reported individuals receiving any special training for work on the village water supply project. Since the Kwakoa project was still under construction at the time of the investigation, it was too early to see if the special training was put to use in any other subsequent activity.

All nine of the villages responded almost unanimously in favor when asked if they thought it was a good idea for villagers to receive special training and learn new skills when worked on development projects. The preferences for training varied between villages and Districts, however. Among each of the Pare villages, training as a mason was the preferred skill, with lesser interest shown in carpentry, mechanics, and agriculture. In all other villages the preferred skill was agriculture. The Kilimanjaro villages overwhelmingly preferred training in agricultural skills, while the Morogoro villages gave secondary but almost equal preference to training in the skills of a mason.

### Village Acceptance of Government Advisors.

Again, when asked if it would be a good thing if government advisors came to the village, households in all of the villages responded almost unanimously in the affirmative. Individual preferences for specific types of government advisors varied widely. Taken as a whole, the replies were about evenly divided between advisors in both agriculture and water development, while a doctor/medical assistant was the third most common answer. Agricultural advisors were favored by the Pare village of Kwakoa and by both Morogoro villages. Water development advisors were favored by the Pare village at Nyata and by the Kilimanjaro village of Msaranga. Ngulu and Mdawi villages voted for both agriculture and water development to an equal degree. The neighboring Kilimanjaro villages of Pumwani-Nanga and Mbuyuni both favored medical advisors.

### Local Attitudes Towards Self Reliance

In an attempt to determine local opinions towards the various types of development approaches, the villagers were asked to compare the relative effectiveness of government versus self-help efforts. One question was worded as follows:

"Some people say that the best way for a village to improve itself is to ask for assistance from Dar es Salaam, while other people say that the best way for a village to improve itself is to rely on its own communal and co-operative efforts. Which way do you think is best?"

An overall total of 57% of the households favored the communal approach, while 37% preferred the government sponsored approach. In terms of whole villages, however, four villages favored each approach, and one village divided its replies between the two. Generally, one could say that the Pare villages overwhelmingly preferred local communal efforts, the Kilimanjaro villages slightly favored government action, and the Morogoro villages were about evenly divided on the question.

Of those that preferred communal efforts 41% did so because of its self reliance aspects, and 33% did so because they considered that it brought faster results. There was no discernible pattern of replies differentiating the three Districts. Of those that preferred government action, three-fourths of all replies were almost evenly distributed among four reasons: more money available, better knowledge, better results, and faster results. The villagers tended to explain both types of preferences in positive, rather than negative, terms. Only 9% preferred communal efforts for the negative reason that Dar es Salaam might not provide help, while an equal amount favored government efforts for the negative reason that local self-help efforts were unreliable.



### Acceptance of Technology

Outwardly, all of the villages are willing to accept modern technology and ways of life over the traditional methods. When asked to compare "modern ways of living" with "old ways of living," all villagers overwhelmingly chose the modern ways. Only 3% of the replies favored the old ways, and a mere 4% said that a combination of the two was best. When asked whether students should be taught "only the things that their fathers were taught" or "about modern machines and methods", the replies again favored the modern aspect. Only 1% preferred what their fathers were taught, while 23% favored a combination of the two aspects.

To another question which asked if "it would be good for young men of this village to receive training at technical schools and then to return to live in this village," a total of 94% answered yes. Half of the yes replies favored agricultural training and another fourth preferred training as a mason, carpenter, or plumber.

### Final Remarks

This paper has described nine Tanzanian villages with respect to their water usage and water-related activities. An understanding of these factors can be helpful in predicting the direct effects and benefits of an improved water supply. Of greater concern for long-range planning purposes is the influence of improved water supplies upon village attitudes and responses towards development. In other words, how can rural water development be best used to foster desired economic and social changes in the rural areas? How can one identify "centres of innovation" or "centres of development" where the provision of water will act as a catalysing agent? The second half of this paper outlined some of the aspects of this assumed relationship between water supply and development that are presently under investigation. No conclusions are yet available, and the subject is very much open to suggestions and comments.

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$7\frac{1}{2}$  per cent. of this is 60,000 gals., or 9,600 c. ft. So that the total available capacity required for both is  $40,915+9,600=50,515$  c. ft.; and dividing this by 700 (the available length of the Tank Sewer), we get 72.16 square feet as the required cross sectional area of the sewage in the Tank Sewer; *i.e.* 58.45 sq. ft. for the City, and 13.71 for the Cantonment. Allowing an average depth of sewage in the Tank Sewer of  $4\frac{1}{2}$  feet, we get the required width of sewage storage section to be:—

$$\frac{58.45}{4.5} = 12.98, \text{ or say 13 feet for the City.}$$

$$\frac{13.71}{4.5} = 3.05, \text{ or say 3 feet for Cantonment.}$$

$$\frac{72.16}{4.5} = 16.03, \text{ or say 16 feet for both.}$$

65. The Reduced Level of the Invert of the 36-inch Intercepting Sewer, at its termination, is fixed at 116.94; and that of its horizontal diameter is 118.44 (*i. e.*  $1\frac{1}{2}$  feet higher); which must be taken as the R.L. of *top* surface of sewage in the Tank Sewer, at its *maximum* depth; and, allowing the floor of the Tank Sewer to fall one foot in its length, the R.L. of its Invert at the upper end would be 114.44, and at the lower end 113.44. For safety in working, the bottom of the suction pipe should be 3 feet below the Invert of the Tank Sewer at the lower end; so that its R.L. will be 110.44; and the floor of sumph should be  $1\frac{1}{2}$  feet lower still, or at R.L. 108.94. The sumph well will be 50 feet long and 8 feet wide, to provide for the suction pipes of the three sets of pumps.

66. The Grit Chambers will be provided with wash-out pipes leading to the nullah; and the Tank Sewer will be provided with an Emergency Outlet, and a 43-inch sewer, also leading into this nullah just beyond the road bridge. The Screens will be a double set, one behind the other, so that one set may always be in position; and they will be provided with proper lifting apparatus. The whole Tank Sewer will be covered with concrete vaulting.

67. For the ventilation of the Gravitation System, an Outlet Ventilating Shaft, 3 feet in diameter and 50 feet high, will be fixed over the sumph; and a nozzle for compressed air will be fixed in this shaft, the action of which was explained in para. 83 of my former Address. For economy, this shaft will be of wrought iron, properly stayed, and bolted down. Suitable openings will be left in the upper parts of the partition walls of the Grit and Screening Chambers, so as to allow of a free current of air flowing from the Intercepting Sewers to the Ventilating Shaft. Perfect ventilation for the Balancing Tank, and for the whole system of gravitation sewers, will thus be provided, as described in para. 83 of my former Address, in which I explained why the natural forces had to be assisted in order to give effective ventilation *all* times. The Air Compressors have been designed of sufficient power to give the necessary air for this outlet shaft, on which the *force* of

*Ventilation System.*

system of the ventilation depends. The two Outlet shafts of the original scheme have been abolished, and the number of Inlet shafts has been increased to suit the extension of the gravitation area. The Shone System of sewers will be ventilated in the way described in the para. referred to. The necessity of a thorough and efficient system of ventilation is *imperative*, for the following reasons :—

- (1) For the oxygenation of the sewage passing through the drains, so as to retard the decomposition until it can be dealt with at the outfall.
- (2) For the innocuous dissemination of any gaseous products generated in the house-drains.
- (3) For the proper disconnection of the house-drains from the public sewers ; for which traps alone are insufficient, as the water in one, or more, may at some time evaporate, or be syphoned out ; or, with bad ventilation, the sewer gas may force the traps. For all these conditions the remedy is ventilation. Without it, no amount of "trapping" will exclude foul air effectually from the houses ; but with it, any foul air which may gain access to, or even be formed in, the drains, will be immediately diffused and removed. As the velocity of the sewage has been fixed at 3 feet per second, or about 2 miles an hour, it is obvious that ordinarily, even from the most distant parts of the city, it will be delivered fresh at the outfall, without decomposing on the way ; but we must provide for contingencies, and it is absolutely certain that, if sewers are not efficiently ventilated, they will, at some time, ventilate themselves in a dangerous manner.

*Engine House.*

68. As Poona is considerably above sea level, the atmospheric pressure will be below the normal, and the maximum suction lift should not exceed 20 feet. The R. L. of pump room floor has, therefore, been taken at 128 ; and the suction lift will vary from 14 to 19 feet, according as the tank sewer is full or empty. This floor will, therefore, be a little below ground level ; but, as it can be drained into the sump, this will not matter. The floors of the rooms for boilers and air compressors, and of the coal store, will be just above ground level. A Coal Store, and Quarters for the Engineer, Drivers, and Engine room Staff, have also been provided, on the scale given by other large towns.

*Rising Main*

69. On the advice of Mr. Santo Crimp, the rising main is to be 25 inches in diameter ; and of mild steel plates,  $\frac{3}{16}$  inch thick. The recent great rise in the price of iron would have caused a considerable increase on the original estimate for a cast-iron main ; and the steel main, with a proper coating, will be just as good. The Bombay Municipality are now adopting them for their new mains ; and Firms are arranging for the necessary bending and rivetting plant.

70. As the rest of the scheme is drawn out on the same lines as *Specifications* the former one, which was fully explained in my former Address, there is no necessity for me to dwell on it. The project, with the specification for the engines, has been sent to Mr. Santo Crimp, in accordance with your wishes. The specification for the Air Compressors, and Ejectors, has been taken from that adopted by the Bombay Municipality for their future extensions of the Shone System, and is based on their actual experience of the Colaba installation. The specification for the steel Main has also been adopted from the Bombay one; and that for the stoneware pipes has been obtained from Mr. Santo Crimp; as also the design for the macerating tank. The largest stoneware pipes will be 15 inches; and above that, moulded cement concrete will be used for the sewers.

71. Quarters will be provided at the farm for the Manager, on the same scale as for the Engineer of the pumping station; and the other *Farm Manager,* farm buildings will be designed under Mr. Mollison's advice.

72. As regards the provision of a trained and competent Farm Manager, I have already, in paragraph 96 of my former Address, stated the terms on which Mr. Mollison considers that he can get a really good man, fit to be trained out here for such a responsible position; and I have ascertained from the Standard Assurance Company, in Bombay, that for a man starting at the age of 25, a yearly payment of Rs. 650 will provide a pension of Rs. 200 a month at the age of 50. The Farm Manager should be brought out by Mr. Mollison, when he returns from leave, and as soon after the works are started as possible. For the first two years he would be thoroughly trained in India under Mr. Mollison, having already had a thorough practical English training. Then, in the third year, he would lay out the farm, under Mr. Mollison's advice, so as to be ready to start cultivation in the fourth year. His pay should be Rs. 300 a month, from date of departure from England; with a free first class passage by one of the cheaper lines, such as the Anchor Line; he should be under the same leave rules as those of the Government Uncovenanted Service; and he should get an increment every second year of Rs. 50 per month, subject to the approval of Mr. Mollison (or his successors), beginning at the end of his fourth year of service, and up to a maximum of Rs. 800 per month. Free quarters to be provided on the farm; and a suitable tent, when necessary, during his first two years. Dismissal to be only for some gross fault, and subject to the approval of the Director-General of Agriculture; with whom the final decision should lie in any matter of dispute, as an independent party. The terms may at first sight seem somewhat high, but they are not really so if you consider the financial result of a success, or a failure, on the farm. Mr. Mollison, in paragraph 11 of his Note (Appendix B of my former Address), and Mr. Doig, late Secretary to Government, Public Works Department, in paragraph 9 of his Note (Appendix A of my former Address), both lay great stress on the absolute importance of

having a thoroughly efficient Manager ; and nothing could be more convincing on this point than a visit to the Ahmedabad and Karachi Farms respectively.

*Machinery.*

73. As stated in paragraph 15, ante, the maximum future quantity of sewage to be pumped will be 3,898 gallons per minute during the day, and half of this at night. The most economical distribution of the power required is to have three engines, any one of which will be able to do the night work ; and two boilers, either of which will drive two of the engines ; also, a third similar boiler for the air compressors. Two boilers, and two pumping engines, and one air compressing engine will work during the day ; and one of each during the night, One of each will *always* be in reserve. The compressed air will be stored at the required pressure in an air receiver, or Accumulator, outside the engine house. A full specification of all the machinery is attached to the estimates. The air mains, when laid, should be tested as described in para. 82 of my former Address. The maximum lift (including 41 feet for friction) will be 190 feet ; so that each engine will be about 112 P.H.P., or about 125 I.H.P.

74. After having seen all the types of pumping engines in this country, and many of those in England, and having compared their "efficiency," and economy in working, I have no hesitation in recommending the Triple Expansion Worthingtons, worked with superheated steam, and Economisers. This was also the opinion of Mr. Doig, late Secretary to Government, Public Works Department ; and I see in the newspapers lately that they have just been adopted for Naini Tal, Calcutta, Lahore, and Delhi ; in the first, second and third cases they are superseding former engines of another type ; and the last case is a second order, given after some years trial of this type on the first portion of the works. Agra and Allahabad are also contemplating substituting Worthingtons for their present engines. Also, they have just been selected for the large installation for the Coolgardie Waterworks, in West Australia, where no less than twenty sets of engines, each of 312 H.P., are required ; and I understand that additional plant, costing £20,000, has been added to the Firm's Works, to cope with this additional work. Messrs. Simpson's tender (at present prices) is £18,736, as per specification drawn out by Mr. Santo Crimp in consultation with Messrs. Simpson & Co. ; for the three engines, three Babcock and Wilcox boilers, a Superheater for each boiler, a Green's Economiser, and everything inside the engine and boiler houses to render the plant complete, and including one 5-ton overhead travelling crane ; the whole delivered, erected, and set to work at Poona. In addition, there will be a charge of £100 for spare parts, and £80 for maintenance for one month. The tender guarantees that the coal consumption of the engines, while doing the maximum work as calculated, will not exceed 2 lbs. of best Welsh coal per I.H.P. per hour, or 17 lbs. of steam through the cylinders ; and that the mechanical efficiency shall not be less than 90 per cent. The pumps will be fitted

with externally-packed plungers, and the Makers guarantee them, and the cylinders, against serious erosion by the sewage for two years. I referred to Mr. Santo Crimp as to the question of cost, and he writes:—  
 “I should say that, at *present* prices in England, engines and pumps of this size are costing about £60 per I.H.P.” Messrs. Simpson’s tender works out to just about £50 per I.H.P.; and includes delivery and erection, and also £300 for the extra boiler for the air-compressing plant, £300 for the “outside-packed” plungers, £130 for the travelling crane, £650 for the three superheaters, and £300 for the economiser, or a total of £2,180; so that the cost of the engines and pumps *alone*, erected at site, will be only £16,556, or about £44 per I.H.P., which is decidedly economical. As prices have gone up of late, and show a tendency to go on rising with the price of iron, it would be as well to give the order as soon as possible; especially as, with their late orders, it will probably take a couple of years to get the machinery made and sent out.

75. The boilers recommended are the Babcock and Wilcox, as there can be no doubt that they are the most efficient and economical for this purpose. The Worthington engines will get nearly all the possible work out of each pound of steam, but boilers vary very much. To work an engine, we have first to make an elastic fluid from water, and then to turn it into water again. This double process involves waste of money; and it is in the manufacture of the steam that economy can be chiefly effected. Suppose we have an engine using 15 lbs. of steam per I.H.P. per hour, and a boiler making 7.5 lbs of steam per pound of coal: we then have a consumption of 2lbs. of coal per I. H. P. per hour. Now, if a boiler can be made to evaporate 10 lbs. of steam per pound of coal, this engine will only use  $1\frac{1}{2}$  lbs. of coal per I.H.P. per hour. On the other hand, if the boiler evaporation remains at  $7\frac{1}{2}$  lbs. per pound of coal, the engine must only use  $11\frac{1}{4}$  lbs of steam per I. H. P. per hour in order to reduce the coal consumption to  $1\frac{1}{2}$  lbs. per I. H. P. per hour. But it is much easier to get a boiler to evaporate the 10 lbs. of steam per pound of coal than to get an engine to work with  $11\frac{1}{4}$  lbs. of steam per I. H. P. per hour, which latter is practically impossible; so you see how much depends on the boiler. Its “efficiency” may be taken to vary from 50 to 80 per cent., according to the type adopted; *i.e.*, of all the heat produced, only 50 p.c. is utilised in a poor boiler, and 80 p.c. in a good one, in producing steam; the difference may be said to go up the chimney, and be wasted.

76. Other ways of economising fuel are:—(1) to heat the feed water of the boilers to the boiling point proper by an Economiser, worked by the *waste* heat on its way to the chimney; and (2) to dry the steam, before it enters the engine cylinders, by Superheaters on each boiler. The saving of fuel by these additions will be about 20 per cent.

77. I have carefully considered the question of horizontal or vertical engines for Poona, and I think that the former are undoubtedly the best suited for this case. Theoretically, vertical engines are the

*Type of  
Engines.*

best; and, for engines running at a very high speed, they are practically the only form that should be considered ; but pumping engines must, of necessity, run at a very moderate speed; and must, therefore, be of comparatively large size ; for such engines the horizontal form has got several decided advantages, such as considerably lower (probably 20 per cent.) first cost, reduced cost of engine foundations, and greater ease of attendance and supervision, entailing the advantage of a smaller staff ; and such engines are now almost universally adopted for this purpose when the lift is not too great. The London Water Companies, who have the best means of comparing various types of engines, have, during the last ten years, adopted the horizontal type in preference to the fine beam engines, formerly used ; and in some instances they have actually taken down beam engines of modern design, and replaced them by triple-expansion direct-acting Worthington Engines. In Bombay, the old vertical compound engines for sewage have been replaced by triple-expansion horizontal Worthington engines. It is true that they have suffered somewhat from erosion of the plungers and cylinders ; but the acknowledged reason is that they have not got "externally-packed" plungers, nor even grit chambers and a tank sewer of sufficient size to allow of the sand, &c., being deposited in them. Similar horizontal Worthington engines are at work in Calcutta, Hyderabad, Simla, and many other places in India, and are giving great satisfaction ; and the Hyderabad President wrote to me that the saving of fuel, formerly used by the old engines, would pay for the new ones in a few years. At Ahmedabad they have Glenfield Beam Engines ; whilst for Surat, Government selected Worthingtons ; and the difference in the cost of the daily working is remarkable. Messrs. Simpson & Co. have made a speciality of pumping engines, and practically make nothing but this type in their enormous workshops, just as Messrs. Willans make a speciality of high speed engines, Messrs. Gwynne of centrifugal engines, Messrs. Hargreaves of mill machinery, Messrs. Thorneycroft of high speed small steamers, and so on ; and, naturally, each excels in their own special line over makers who go in for general work.

78. But even supposing that some other type was equally efficient, and somewhat cheaper, (both of which are very unlikely), still I would strongly recommend the Worthingtons, because Messrs. Simpson & Co. have a large connection out here, and it is of the utmost importance to them to maintain their reputation. I know of two cases (Sukkur and Surat) in which they lost many hundreds of pounds rather than not carry out their guarantees. Moreover, as they do so much work out here, they can afford to keep up permanently an experienced staff for erecting, and periodically inspecting, their engines, under a first class mechanical engineer, who is their Agent out here. The advantage of this yearly inspection is very great as regards the life of the machinery ; and, as only a small sum is charged for it, and a full report is sent after each inspection, every Municipality that has these engines has adopted this

system, as it affords a check on the capability of the Engineer and his Staff; and any little faults are brought to notice, and corrected, before they can develop serious damage. An ordinary firm would merely send out a good erector from their workshop, who would probably have had no experience of this country; and, if anything went wrong subsequently, they would have no interest in rectifying it, as the order would have been an isolated one. The Ahmedabad Municipality rejected my advice when they were getting their third engine, a couple of years ago, and ordered it from Messrs. Glenfield & Co., who had made the first two engines. That firm said that they could ensure as great "efficiency" as the Worthingtons; but not only is this not the case, but the engine is badly balanced, and a heavy counterweight will have to be put on the shaft to make the engine work steadily. When I was there last December, the Indicator diagrams which I took were the worst I have ever seen, and showed that there was a large waste of fuel going on. A subsequent set of better diagrams shows that the efficiency even then was only about 70 p. c., and the fuel consumption was equivalent to a little more than 3 lbs. of best Welsh coal per I.H.P. per hour! Some of the Ahmedabad Municipality have visited the Surat engines, and have told me how much they now regretted that they had not ordered a Worthington. For the Poona Cantonment Waterworks Pumping Station, the Secretary of State sent out a horizontal Worthington, and a local Bombay firm was given the erection; but it gave so much trouble that Messrs. Simpson's agent had to be called in, and he found that it had to be taken to pieces and re-erected. For the Ahmedabad Sewage Scheme, Mr. B. Latham has recommended engines, by an unknown maker, at an impossible price for really good work that would last; and they are expected to work at the impossible rate of  $1\frac{3}{4}$  lbs. of coal per Pump H. P. I showed the papers to Mr. Santo Crimp, and he confirmed what I have just said. Mr. Latham has had no experience in *Mechanical Engineering*, and has no partner (as Mr. Santo Crimp has) with this particular experience, so that he is apt to be misled by plausible makers. In the case of Margate, he recommended engines which have since had to be removed; and in the case of Ahmedabad his recommendation would have been assuredly as disastrous; and the makers would have had no further interest in the matter, as they would know that it was only a chance order. It is a double guarantee to deal with a well-known firm who make a speciality of pumping engines, and who have also to keep up an Indian reputation, and who have shown that they are willing to lose considerable sums rather than risk that reputation.

79. As regards the relative charges of the Outfall works, between the City and the Cantonments, I think that the latter should be debited with half the cost of the 24-inch Intercepting Sewer, from the end of their 18-inch sewer to the balancing tank sewer; and with one-fifth of the tank sewer and its appurtenances, the engine house and quarters for the staff, the rising main, and the macerating tank. The Lieutenant-General Commanding the Forces has told me personally that the Military authorities do not wish to join in the farm.

*Distribution  
of cost of the  
Outfall  
Works.*



*Improvement  
to the Water  
Supply.*

80. I now come to the project for improving your Water Supply, which work is now to be carried out concurrently with your Drainage scheme. As ordered by Government, this is drawn out on the lines of the project sketched out by Mr. Doig for a full supply from the Karakwasla Canal at 20 gallons per head per day. Your present population may be taken as being well under 1,30,000; and the pipes are calculated for a future population of 1,58,000, to give the full day's supply in 500 minutes.

*Settling Tank*

81. The settling tank is to be of the "continuous flow" pattern, which has been so successful at Meerut that it is to be adopted for Hyderabad. It is both cheaper and more effective than the old kind. To allow for the periodical closures of the canal for clearance, this tank has been designed to hold six days' supply; and there is room for extension at the site selected by Mr. Doig, which is alongside the canal, and 1650 feet north of the old circular tanks belonging to the Municipality. Its length is 1,000 feet, breadth 300 feet, and the depth  $8\frac{1}{2}$  feet, including coping. It is divided into five compartments by thin brick-and-chunam walls starting alternately from each side, and running to within 50 feet of the opposite side; so that the water will follow a zigzag course with a very low velocity. The water will enter the first compartment by a channel along its upper edge, which will have a hinged weir in front, to be adjusted to the canal level; so that the water will always pass over it in a thin film, about half an inch deep, with as little disturbance to the contents of the tank as possible. The first four compartments are furnished with wash-out pipes for removal of the silt. For a daily supply of 26 lakhs gallons, the velocity will be about  $\frac{1}{32}$  inch per second; and the water will be about 140 hours in the tank between its entry and exit. A bye-pass will also be provided, for direct communication between the canal and the regulating chamber, for use when the tank is closed for cleaning. The floor of the regulating chamber is  $1\frac{1}{2}$  feet below bed of settling tank, and the pipes are laid at this floor level.

*Filter Beds*

82. In accordance with your own wishes, and Mr. Doig's Note, I have not entered filter beds and a pure water reservoir in the estimate, as the re-arranging of your pipes, to ensure a larger supply with a greater pressure, is a matter of the first importance. But I would draw your earnest attention to paras. 5, 6 and 7 of my former Address, and would strongly urge you to carry out these additions as soon as the urgent work of the pipes is done; and not allow yourselves to be lulled into a fancied security, simply because analyses at certain periods have shown that the canal water *at those periods* was pure: or some day the city may suffer the fate of Hamburg, whilst the Cantonments enjoy the immunity of Altona.

*High and  
Low Service.*

83. Owing to the levels of the ground, the supply to the city must be divided into a high and a low service, as suggested by Mr. Doig; the former providing for about one-fourth of the population. This is absolutely necessary to ensure an effective head of 20 to 30 feet

above ground, as a minimum, all over the city. For this high level service, the water will be drawn off from the settling tank to a pumping station near the two old circular tanks, 1,650 feet from the settling tank ; whence it will be raised by Triple Expansion Worthington Engines into two steel tanks, each holding  $1\frac{1}{2}$  lakhs gallons ; and supported on towers, as at Surat. Rock is available about two feet below the surface at this spot, so that the foundations will be cheap. The tanks are to be  $42\frac{1}{2}$  feet in diameter and 19 feet high, and the top of the towers will be 16 feet above ground level.

84. For the H. L. service, the city is divided into two districts ; and for the low service, the rest of the city is divided into five districts. The latter are served by mains taking off direct from the regulating chamber of the settling tank. The pressure over the low service area will ordinarily be 6 to 8 feet *more* than those shown in the Statement ; as those calculations start with a level only six inches above the bed of the settling tank. Similarly, the pressure over the high level service area will normally be 10 to 15 feet more than those given in the Statement, as the starting point of these is the bottom of the H. L. tanks.

85. With the assistance of your Engineer, all the existing pipe lines have been laid down on a map of the city ; and are to be utilised as far as possible, either by being left where they are, or by being shifted to other parts of the new system, where suitable. The surplus consists chiefly of small pipes of 4, 3 and 2 inches in diameter, which will be utilised as "circulation pipes" for connecting the ends of pipes of the new system, where this is necessary to avoid "dead ends" ; and they will also be available for subsequent branches in the city, which will be required as the number of house-connections increases.

86. The simplest and cheapest form of public service is to have a number of one-foot lengths of 2-inch W. I. pipes, screwed at both ends, and with a socket at one end of each length ; and a number of 2-inch tees, screwed to take  $\frac{3}{4}$ -inch cocks. The number of cocks for any locality should be about one for every 50 persons who are likely to draw water from that service ; exclusive of those who will have house-connections provided for W. C's., and who can easily have an extra tap inside the house. The cocks are fixed alternately on opposite sides of the main horizontal pipe, so that there is 2 feet between each pair of cocks on the same side. The horizontal pipe is supplied by a vertical pipe (or two if there are more than 12 cocks on the service), connected with the main, and controlled by a small valve. The ends of the horizontal pipe are closed by screwed caps, and supported on small masonry pillars. A pavement is constructed below the service, with a gutter leading to the nearest sewer, and a gully trap at the junction. Stone blocks are placed under each cock, for the pots to rest upon. This will allow of the present insanitary dipping cisterns being abolished, which is a most important point. For standposts, where only one cock is required, a cheap and very satisfactory design is that of Messrs. Garlick & Co., of Bombay, which costs Rs. 65.

*Public Services.*

87. Hydrants, for fire service, will be fixed at about every 500 feet apart, in the principal parts of the city; and a certain number of cattle troughs will be erected where they are required.

*Working  
Cost.*

88. At first, the H. L. supply will be about  $6\frac{1}{4}$  lakhs of gallons per day; and the engines will consume 5 cwt. of Welsh coal, or  $6\frac{1}{4}$  cwt. of Singareni, per day, or say 120 tons per annum; which, at Rs. 14 per ton, will cost, say, Rs. 1,700. The engine room stores will cost about Rs. 50 per month, or Rs. 600 per annum. The repairs for the first couple of years will be trifling; and Rs. 700 per annum will be ample for many years to come, for repairs and contingencies; so that the total cost of working the engines (exclusive of establishment) may be taken at Rs. 3,000 per annum. The Engine room Establishment will be:—

		Cost per month.		
1 Engine Driver, at Rs. 100 per month	...	...	Rs.	100
2 Oilers at Rs. 15 each	do	...	„	30
2 Firemen, at Rs. 15 each	do	...	„	30
3 Coalers, at Rs. 10 each	do	...	„	30
Total...				Rs. 190

or, say, Rs. 2,300 per annum.

89. The Maintenance Establishment for the Waterworks, after construction, will be small; as the Engineer Superintendent, and the Fitter of the sewage pumping station, can also supervise the waterworks engines; and, similarly, the Drainage Engineer and his Establishment can look after the water pipes and their fittings; the only additional staff that will be required are three turncocks, at Rs. 10 or 12 each, and two men at the settling tank, on Rs. 10 and 15, respectively; or, say, Rs. 700 per annum. The repairs and contingencies may be taken at Rs. 1,000 per annum; so that the whole cost of working the system will be:—

Engine Room Expenses	...	...	...	Rs.	3,000
Do. Establishment	...	...	...	„	2,300
Maintenance do.	...	...	...	„	700
Repairs and Contingencies	...	...	...	„	1,000
Total per annum...					Rs. 7,000

The annual cost of your present insufficient and insanitary arrangements is Rs. 4,000; so that the *extra* cost will only be Rs. 3,000 a year.

The Engineer for constructing the drainage works, and his Establishment, can also supervise the construction of the waterworks; and the provision for tools and plant for the former will do for both, as very little will be required for the latter. Maistrees and petty establishment, as required, can be charged to works, as usual.

*Waterworks  
Machinery.*

90. The machinery will consist of two Triple Expansion Worthington Engines, each capable of lifting 1,600 gallons per minute to a height of 60 feet; so as to provide for the future adoption of filter beds

and a pure water reservoir ; and also be able to keep pace with the *maximum* draw-off from the H. L. Tanks. The steam will be provided by two Babcock and Wilcox boilers, each capable of driving one engine. As the tanks will provide nearly half a day's storage, there can be no danger, with engines of this capacity, of the supply running short. The cost of the above machinery, delivered at site, and erected, with all pipes and valves inside the engine house, will be £5,400. There will also be one economiser, at a cost of £153; and each boiler will have a super-heater, at a cost of £185 for the two. The saving of coal with these two additions will be fully 20 per cent. There will also be a W. I. chimney of suitable size, complete with base plate, guys, and anchor bolts, at a cost of £56. These prices also include delivery at site, and erection. In addition, there will be a charge for maintenance, for one month, at a cost of £40.

91. The machinery will be almost the same as that erected lately at Naini Tal, the engines of which are about 30 H. P., and do not consume more than 25 lbs. of steam per H. P. per hour. This is very satisfactory for pumping engines of this small size. They will also be very similar to those recently erected for the Hyderabad Municipality, which the President tells me are working with great economy, and very satisfactorily.

92. All mains, and their branches, are to be controlled by suitable *Sluice Valves*. sluice valves, each fitted with an indicator to show how far it is open; and enclosed in suitable road boxes, with locking lids.

93. The inlet from the canal to the settling tank will be provided with a Kent's Irrigation meter, as also the channel to the H. L. Tanks ; *Meters*. and the two city mains from the settling tank will each have a Kent's "Venturi" meter fixed on it ; so that the quantity of water used may be properly registered and checked.

94. The surface level of the water in the settling tank is taken at *Storage provided*. three inches below the normal level of the canal, which latter is 215.85. In the hot weather, the canal level sometimes falls two feet below this ; and Government have been asked to allow of a moveable weir being erected across the canal, just below the inlet, to allow of the surface level being raised to the normal for a couple of days before a closure, so as to allow of the full supply being stored for use during the closure. Alongside the H. L. Pumping Station there are two old circular tanks, formerly made as settling tanks; but which were found to be unsuitable for this purpose, as the storage was too little. Their inner diameters are 133 and 142 feet, and they are excavated to R. L. 212.46 and 211.11, respectively. It is proposed to clean them out, and to deepen them to the suction level of the engines, *i.e.*, about 19 feet below ground level, the R. L. of the ground here being about 221. They can then be used as sumpshs for the pumps; and they will provide a considerable amount of extra storage, amounting to about 30 lakhs of gallons. The excavated stone can be used both for the concrete and masonry of the different

works of both the drainage and water works; so that the net cost of the extra storage obtained will be small, probably not more than Rs. 10,000, or at the rate of about Rs. 4 per 100 cubic feet of the excavated rock. There is a meter on the adjoining main from the canal to the city; and, when these pipes are removed, a connection can be made for a by-pass, from the meter to the circular tanks; which are already provided with a wash-out, leading to the adjoining nullah.

*Katraj  
Aqueduct.*

95. The levels show that, by taking a point sufficiently high up on the old Katraj pipe, the necessary filters can be placed there, and the pure water run down to the low service reservoir. This will probably be the cheapest way of getting an extra supply as the population increases in the future; and I will draw out the plans and estimates for this, and for the filters, and a pure water reservoir in connection with the settling tanks, so that these works can be carried out hereafter as soon as the Municipality decide on them.

*Cost of  
Canal Water.*

96. As regards payment for the extra water, Government will probably agree to the terms mentioned in their offer in 1893, *viz.*, to give the *whole* supply at the rate now charged for the present  $7\frac{1}{2}$  lakhs of gallons per day; which is Rs. 10,000 a year, or about 7 pies per 1,000 gallons; the minimum yearly future payment being Rs. 20,000. The charge for about 26 lakhs gallons per day will, therefore, be about Rs. 35,000 a year; or Rs. 25,000 more than you now pay.

97. If Government agree to this, I cannot but think that it will be reasonable; as you must remember that the canal has been made with public money, for which Government have to get as good a return as possible; and there is no doubt that water for drinking purposes must be considered more valuable than for irrigation. Also, the canal will lose most of the revenue it gets from the future farm site, as this will then be chiefly irrigated with the effluent; and this loss will probably approximate to Rs. 25,000 a year on the average. Moreover, the Irrigation Department will have to reserve the required supply in Karakwasla, and cannot calculate on it as being available to supplement the irrigation supply at all.

98. It is true that the irrigation rate of Rs. 40 per acre for sugarcane is theoretically equivalent to 412,000 cubic feet of the storage in the Karakwasla Reservoir, as calculated on an *average* of the *whole* sugarcane area along many miles of the canal; but, for the reasons given in para. 25 ante, this rate cannot be taken to govern the rate for any other object at one special point near the headworks, up to which point the loss by leakage is small; and where there is no waste to allow for, as *all* the water taken there will be measured *and utilised*. For these reasons, it is much fairer to take the rate as calculated on the quantity found by Mr. Mollison to give the *best* crop, (*viz.* 200,000 cubic feet), when applied *without waste*; and this works out to a little over 6 pies per 1,000 gallons.

99. The ryot gets no benefit, but rather a loss, from the excess water used by him through his carelessness ; but Government have to allow for this, as it cannot be prevented. You, however, would get a direct benefit if this allowance for waste was made in your case, as you will profitably use *all* the water supplied, and will get full value for the price paid; just as Mr. Mollison got the full benefit for his Rs. 40 per acre, although he only used *half* the *average* allowance, and wasted none. The result of such waste by the ryots is seen in the damaged fields of the Manjri Farm site, and in the streams flowing in every nullah that drains the sugarcane area ; which water might have been of great benefit to other ryots lower down the canal, if the sugarcane men had exercised the same care in applying the canal water as they would have done in the case of well water.

100. You have experienced this year how inadequate your present water-supply arrangements are ; and repeatedly of late years you have similarly, but to a lesser degree, felt the danger and inconvenience resulting from the drying up of the old native aqueducts, in the beginning of the hot weather, or even earlier ; and, with a growing population, this difficulty must become more and more prominent each year. You *must* come to Government for more water in the end ; and the terms will probably be more onerous in the future, if the present opportunity is lost ; as the value of a commodity is regulated by the urgency of the demand for it. The scheme now proposed will ensure you an ample and good supply for all time. When proper filter beds are constructed for the Katraj Aqueduct, you will probably be able to economise the use of the canal water to some extent. Even now you always use more canal water than the nominal daily supply of  $7\frac{1}{2}$  lakhs gallons, and your yearly payments are Rs. 2,000 to 3,000 more than the amount mentioned.

101. You will observe that my calculations regarding the quantity of sewage, or of water, to be dealt with, and the cost of maintenance, or working, are based, generally, on the *present* normal population. The reason for this is that these quantities can only increase with an increase of the population, and of the houses ; and this will, of itself, lead to a corresponding increase in the total of the taxes, which will pay for the extra cost of dealing with the increased quantities. The average number of people (including children of all ages), occupying each house at present, is between nine and ten.

102. The amount of the General Abstract of the Sewerage Scheme, Appendix C, is Rs. 25,18,289, as against Rs. 30,13,584 (including 12 lakhs for the additional proposal about the farm) of the previous scheme. The reduction would have been larger but for the inclusion of nearly two lakhs for house-connections in the General Estimate, instead of their being charged to the houseowners, as before. The conversion of privies into W. C's. will cost Rs. 4,54,223, instead of the former estimate of 10 lakhs ; so that, taking the whole scheme, there is a total reduction

*Cost of the  
Sewerage  
Project.*

of about 10½ lakhs. The way in which the expenditure should be spread over the three years, allowing for the purchase of all English articles in the first two years, and for the local work being distributed over the three years, is given in Appendix D.

*Cost of the  
Waterworks  
Project.*

103. The cost of the Water Supply Project is given in Appendix E. The settling tank (which is also the storage reservoir) costs about a lakh more than Mr. Doig's rough estimate; and there is a similar excess over his rough estimate for pipes; and about one-and-a-half lakhs excess over his rough estimate for the H. L. tanks and the machinery. Of course, Mr. Doig's figures were only for the general outline of a scheme; and, moreover, the present scheme has to provide for 50 per cent. more water than Mr. Doig calculated for; as it has to suffice for the probable increase of population for 20 years after the works are finished, *i. e.*, more than 30 years after Mr. Doig's estimate; and it has also to provide the extra water for the sewerage. Two years will suffice for carrying out the water-supply, and the way in which the expenditure will be distributed over these two years is given in Appendix F; allowing for the purchase of the English materials in the first year, and for the local work being spread over the two years. I propose to start this work concurrently with the Drainage Scheme, so that any minor matters may be done in the 3rd year, to enable the Drainage Scheme to begin working complete at the end of that year.

*Revenue, and  
Permanent  
Establish-  
ment of the  
Effluent  
Farm.*

104. The revenue from the effluent farm, and the cost of its permanent establishment, are given in Appendix G. The latter is based on para. 33, ante, and on Mr. Mollison's two Notes (of last year and this year), and their accompanying Statements. I think it will be allowed that I have now taken very moderate amounts for the net profit on each of the areas; and, for the reasons given in paras. 16 and 21 ante, even if these amounts are not exceeded, the area of the sugarcane will assuredly increase in the near future.

*Rates of pro-  
fit for each  
crop.*

105. As regards the amounts per acre taken by me, you will note that for sugarcane I have kept to Rs. 300 per acre; although, from para. 20 ante, you will see that I might have taken Rs. 400, or more, under the authority of your President; and, from the Statement of the comparative experiments with sugarcane, attached to Mr. Mollison's Note of this year, Appendix B, I might have fairly taken Rs. 350, or, more; as, although the value of the effluent goor was 2½ per cent. less than that of the *poudrette* goor, yet the quantity of the former was 10 per cent. more than that of the latter, leaving a net gain for the former of 7½ per cent. When our knowledge of the best mode of using the effluent equals our knowledge of *poudrette* (which will be in 2 or 3 years), this gain ought to be increased, with intelligent and careful supervision.

106. As regards the rate for Lucerne, you will see from the statement of comparative mauure experiments with fodder crops

attached to Mr. Mollison's Note of this year, that allowing 200 lbs., dry weight (equal to over 250 lbs., as wetted for sale) per rupee, the profit of what was actually cut during one whole year would have been Rs. 336-12-0 per acre ; and from para. 24 ante you see that, even at a rate of 250 lbs. of dry Lucerne per rupee, the amount would have been over Rs. 300 if the effluent had been applied throughout the year in the way which we now know is the most suitable. In Bombay the retail rate is Annas 8 for 28 to 30 lbs., or, say, 60 lbs. per rupee ; the Railway charge for it by passenger train is As. 10 per 80 lbs. ; so if we sell it here at even 200 lbs. per rupee, dry weight, the carriage to Bombay on this amount will be Rs. 1-9-0, which gives a wholesale rate of 80 lbs. dry weight per rupee at the railway station in Bombay. This allows a large margin for distribution, &c., as the above quantity will weigh over 100 lbs. when wetted for retail sale ; so that the seller would be even able to lower his retail rate. The demand in Bombay is now very much in excess of the supply, and a lowering of the retail rate would increase the demand considerably. The same result would assuredly occur here ; and we should have no difficulty in disposing of an average of 400 maunds per day, in both places, even at this rate.

107. As regards the fodder crop rates, for such crops on land under the Canal, you will see from the statement attached to Mr. Mollison's Note of last year, Appendix B of my former Address, that, even at the liberal rates then taken for the fodder, the net value per acre of the first crop in each case was:—*sundhia* Rs. 86-7-0, American *sorghum* (Amber) Rs. 104, American *sorghum* (Collier) Rs. 92-14-0, and maize Rs. 101-7-0. From the statement attached to his note of this year, Appendix B, it is evident that the experiment of growing a second crop from the stubble of the first crop was a comparative failure ; but, from the rapidity of their maturing, four crops of *sundhia*, and three of the others, could easily be grown from fresh seed in the year ; and the net profit per acre would then vary from Rs. 250 to Rs. 300, instead of the Rs. 200 which I have taken. As explained by Mr. Mollison, this area of fodder crops will be cultivated in rotation, with part of the sugarcane area, so as to prevent deterioration of the land.

108. As regards the fodder crops which are to be grown during the monsoon only, on the light land around the macerating tank, (not under the canal), in accordance with para. 12 of Mr. Mollison's Note, Appendix B, (during the period when the heavy land is sodden and wet, and therefore, not in a condition to purify the effluent), there is no reason why we should not get a first crop, and a stubble crop, of *sundhia* and the *sorghums*, as we actually did last monsoon ; and one crop of the others ; giving a profit of from Rs. 98 to Rs. 150 per acre, as shown in last year's statement ; so that my estimate of Rs. 70 per acre is very moderate. Our fodder crops will be about equivalent to an addition of 2,000 acres to the present area, which is a trifle ; so there will be no danger of flooding the market.



109. I would further point out that in this matter we are not going on theory, or guess work ; but on the actual results of identical experiments, carefully carried out for a whole year ; and the rates which I have taken allow a large margin for contingencies from the rates actually obtained. During the current year, Mr. Mollison will carry out similar experiments with various pulses, and native vegetables, as well as further experiments with sugarcane; and these, or other similar experiments, will be continued; so that by the time our farm is ready, we shall have accumulated a lot of valuable experience.

*Loans re-  
quired.*

110. In Appendix H I have given a statement of the loans that will be required, both for the sewerage (including the conversion of privies into W. C's.) and for the water-supply ; on the understanding that the yearly charges on these loans during construction, and until the farm is in full work, will be added to the capital cost. I trust that Government will agree to this, as I think that it would be practically impossible for you to raise temporary taxes to cover these charges during those years ; and as this is to be a working, paying concern, like a railway, the same terms, as regards these charges, might fairly be applied to it as to railways. The relative experience of Surat and Ahmedabad has proved that it is unadvisable to levy a tax for a sanitary work until it is finished, and the people are able to appreciate the benefits obtained ; and then, as in the case of Ahmedabad, they do not object to pay. In Surat, the people had to pay the extra tax during the years of construction, and there was much discontent, which arose to a very serious pitch.

*Rate of  
Interest.*

111. In both cases I have taken the interest at 5 per cent., as the present rate of  $3\frac{1}{2}$  per cent. Government Paper is well below par. This Government has to pay the Government of India a half per cent. more interest for all loans ; and this extra rate is again charged when the money is passed on to a Municipality.

*Periods of  
Loans.*

112. For the sewerage loans I have taken a period of 30 years, which is the period taken for the calculations of the sewers, &c. For the waterworks loans the period taken is for 20 years, for a similar reason. The latter period is also taken for the machinery of the Sewerage Scheme ; although it will probably last for the full time if a proper engineer is got for it, and it is kept in order.

*Profit and  
Loss.*

113. In Appendix I the final Profit and Loss Account is shown. Owing to only half the area of sugarcane being grown in the fourth year of the works, (which corresponds to the first year of the farm), there is an estimated deficit in that year of Rs. 92,437, which has been added to the loan account, for the reasons already given ; also, the probable extra charge for canal water for the third and fourth years, *i. e.*, until the farm profits of its first year are in hand. The small extra cost (Rs. 3,000) of the working expenses of the waterworks, over the cost of the present system, has been left for you to deal with out of

current revenue, so as not to complicate matters. The final result, after the fifth year, shows an estimated deficit of Rs. 12,228; but, for the reasons already given, I fully anticipate that this will be more than covered by the increased revenue of the farm over what I have estimated; and by the sale of surplus effluent, or its utilisation on a larger area by the Municipality, in the near future.

114. In this Profit and Loss Statement you will see that I have entered *all* charges that will come on the debit side, for both sewerage and water-supply; and under the credit side I have entered the moderate yearly charge for the W. C's.; and your present *net* expenditure on your drainage and water-supply, which will be saved in the future.

115. As regards the practical carrying out of the works, it will be absolutely necessary for you to depute your powers as regards contracts, and other details of the work, to a *small* Committee; which you will be able to do under the revised District Municipality Act. It is obvious that a large body like the Municipality could not possibly attend to all the details and references that must continually arise during the progress of such a work; as these would necessitate continual meetings, most of which would probably have to be adjourned for want of a quorum; and the delay would be intolerable, and harmful to economy and efficiency. For similar reasons it is necessary that the Committee itself should be small, but representative; and I would suggest your President, the Chairman of the Managing Committee, the Hon. Mr. Gokhle, Mr. Kanetkar, Mr. Kelkar, Mr. Nagurkar, and myself; of whom four should form a quorum. *Works Committee.*

116. And now, having explained the scope of the proposed schemes, I would say a few words to you on the urgent necessity for carrying them out with the least possible delay. The usual criteria adopted as evidence of the health of any community are:—(1) The general death-rate, (2) the zymotic death-rate, and (3) the infant mortality. Of these, the gross death-rate is a fairly simple, and, in the main, an accurate measure of the prevalence of disease. In the beginning of my former Address I referred to your death-rate, which, on the statistics *then* available, was apparently 28 per 1000, on an average of five years. The system of registration was, however, admittedly defective; and, in August-1898, Major Reade, your late Chairman, organised a more accurate system; and also instituted a rough periodical census, according to which the death-rate in the succeeding six months was shown to average no less than 33 per 1000; and the population in January 1899 was 1,25,790. In the next month, plague broke out, and the returns of the following months of that year cannot be fairly taken as any indication of the ordinary death-rate. But during the current year, although the deaths from cholera and small-pox have seldom been more than 4 and 5 a day, and plague was absent, your death-rate has been very high, averaging from 50 to 60, or even more, per 1000. As the rate in Cawnpore which *The high death-rate.*

attracted the attention of Parliament, and practically set on foot the sanitary works in the great towns of the N.-W. P., was only between 50 and 60 per 1000, the serious pass at which you have arrived is evident.

117. I would again impress on you that this great loss of life is *directly* caused by the insanitary condition of the town, as stated to you by Major Reade in his farewell speech; and Mr. Santo Crimp has told you that you can expect no amelioration of your condition until those sanitary defects are remedied. The average death-rate of the 33 largest towns in England is only 20·8; the highest being Plymouth, with 26·4; and the lowest Croydon, with 13·1; whilst in the great prison at Milbank it is only 12; and in the whole of the English prisons it only averages 11·4. The standard rate in England is taken as 15 per 1000, and the actual rate for the whole of the United Kingdom is 17·7. A normal death-rate in India would probably lie between 20 and 25 per 1000; so that probably *one-third* of your normal deaths would be saved by the carrying out of proper water-supply and drainage schemes.

*Responsi-  
bility for this  
death-rate.*

118. In my former Address I referred to the causes of the bad state of your public health. The strenuous efforts made by your staff to keep the town clean, can only have a very superficial and minor effect as long as the water-logging and pollution of the soil continues. Both Mr. Santo Crimp and Major Reade have laid great stress on this; and urged you to lose no time in undertaking the necessary works. After long droughts, such as we have in India, the surface-soil becomes cracked and fissured, and loses its cohesion; and, thus, foul surface deposits get down into the water zone of the wells sunk in the subsoil; and the malignant germs of disease there find a congenial home, where they can multiply and spread. The *certainty* of a considerable reduction in the death-rate being manifest from the statistics of various countries, the neglect of those who have the power to carry out the works which will ensure this reduction is a very serious indictment; and I must endeavour to awaken your conscience in this matter, as your duty is to understand the responsibility that rests on you, at the present moment, in this question of a *preventible* high death-rate. If 70 to 100 murders, or suicides, occurred here each month, you would naturally be horrified, and urge that any possible means should be taken, or expense incurred, to put a stop to such a state of things; but the same number of *preventible* deaths each month is looked on, with more or less complacency, as a thing that cannot be helped. But statistics all over the world show that it *can* be helped, *if* money is spent properly in *removing the causes*; and, if that money is not now spent here, *you* will be incurring the responsibility for all these preventible deaths, to say nothing of the much larger amount of preventible ill-health resulting from the same removable causes; because *you*, at least, cannot now plead ignorance of the proper course to pursue.

119. Why are Indian Municipalities so slow to adopt remedies which science and history have pointed out? Is there any doubt as to the correctness of this universal testimony, and its conclusions; or are they indifferent to human suffering, and to the loss of human life? Thousands, and tens of thousands, are allowed to perish annually in India through preventible disease, because more money, more faith, and more energy are required to deal with this matter satisfactorily. It is *not* because there is any doubt as to the correctness of the conclusions arrived at; but because, through apathy and supineness, they fail to appreciate that the direct cost of thus saving life would be infinitely less than the wealth indirectly lost through the unnecessary sacrifice of life. But, because the immediate effect of sanitary defects is not made apparent at once, the causes are more or less ignored; investigation is often imperfect, knowledge indefinite, and popular prejudice is often at fault. Such things should not be; and it is only through persistent education of the public mind that this question of mere finance can be set in its proper, and secondary, place; and the matured conclusions of sanitary science carried into effect.

*Municipalities  
apathetic  
about  
sanitary  
matters.*

120. The people of India, generally, are uninformed on such subjects, and cannot appreciate the effects of filth, foul air, and impure water in generating and aggravating epidemic and endemic disease. They are too much inclined to regard epidemic disease as a visitation of God, which cannot be averted; and they object to be taxed for the removal of injurious sanitary defects, because they have, for generations, been accustomed to these defects; and, therefore, do not regard them as the evils that they really are.

121. Some members of Municipalities are also often unwilling to incur the odium of raising the necessary taxation in such cases, unless they can escape the consequent unpopularity by showing that they acted under compulsion. Men who are prepared to incur popular displeasure, in order to do good to the people against their will, especially when that displeasure may involve loss of local dignity, are never numerous; but I trust I have convinced you that it is necessary to look at this subject from a public-spirited point of view, solely for the benefit of the ignorant people. I would ask you to take the matter up diligently; and, as far as possible, make yourselves acquainted with its details and results; and not merely view it from the one point of extra taxation, or of saving money at the expense of human life. You have got the best expert advice that was available, and should rely upon it. Do not put your trust solely in rules and regulations; but study for yourselves the simpler laws of health; and, when you have learnt them, obey them in your lives. Only in that way can you secure health and happiness in your houses, and afford a good example to your neighbours.

*Final advice.*

122. The aim of house-sanitation is to lower the death-rate, and to promote the health and well-being of the occupants of the houses. Everyone has a direct interest in lowering his own death-rate, and that of those

dependent on him ; and in living his own life under such conditions as are most conducive to health, happiness, and capacity for work. No drainage system can be automatic, and it is necessary to distinguish between a house-drain and a sewer ; as, although a sewerage system may be perfect in itself, individual houses may suffer through neglect of their own house-drains. It is, therefore, necessary that these house-connections should be properly made, and also be taken reasonable care of ; and that the traps should not be choked by rags, boots, or even stones. It almost seems incredible that such stoppages have been wilfully caused in Bombay. They are, however, much less likely to occur here, as the offender and his family will be the immediate, and only, sufferers.

J. C. POTTINGER, M.I.C.E.,  
Sanitary Engineer and  
Member of the Sanitary Board.

## APPENDIX A.

BOSTON, MASSACHUSETTS, 20th March 1900.

To J. C. POTTINGER, Esq.

*Sanitary Engineer and Member of the Sanitary Board,  
Poona, Bombay Presidency, India.*

DEAR SIR,

I am in receipt of your letter, of the 19th ultimo, in regard to the effect of nitrogenous fertilizers upon sugarcane.

2. I desire to call your attention to the fact that, since Mr. Leonard Wray (whose reputation is well-known in this country, and who is highly regarded) wrote "The Practical Sugar Planter" in 1848, our ideas of the fertilization of plants have undergone a wonderful evolution.

3. It is now known that nitrogenous fertilizers are highly essential, not only to a heavy crop, but also to the percentage of sugar in the cane. It is true that where a great excess of nitrogenous fertilizer is employed, there is a tendency to produce a heavy crop with a somewhat lower percentage of sugar. But even in this case the *total* sugar produced per acre is *increased*. There is no tendency to the production of gluten, as stated by Mr. Wray, even when an excessive amount of nitrogenous fertilizer is used. Even nitrate of soda, (the most concentrated and active nitrogenous manure), can be used on sugarcane with good results; provided that heavy rains do not remove it entirely from the soil before it can be taken up by the plants. In the State of Louisiana, the use of nitrogenous fertilizers has grown enormously during the past twenty-five years. Fertilizers of this character are now regarded as essential to the production of paying crops.

4. I should say that it would be perfectly safe for you to use the purified tank sewage, of which you speak, even without subjecting it to nitrification in the bacteria beds containing coke and clinkers.

5. I am not surprised that you found good effects resulting from the use of this fertilizing material. I think you can safely apply even larger quantities without any material injury being done. The slightly decreased percentage of sugar in the cane, which is accompanied with the large increase in the weight of the crop, will without doubt prove advantageous to the grower; but, as I have said above, even an excessive fertilization with nitrogen will only produce a moderate decrease in the sugar; and will not be at all hurtful in the manufacture of the sugar. Nevertheless, for economical reasons, care should be exercised not to use an excess of this material, and so waste a valuable manure. Nitrogen, however, must be regarded as essential in fields which have long been under cultivation, as an absolutely necessary ingredient for every fertilizer employed for the growing of sugarcane.

Very truly yours,

(Sd.) JAMES WILSON,

*Secretary to the Agricultural Department, U. S. A.*

## APPENDIX B.

**NOTE by J. A. Mollison, Esq., Deputy Director  
of Agriculture, on the Crop Experiments with Effluent.**

In the following Note, I propose to give the results of experiments which were undertaken at the Kirkee Government Farm, to test the effect upon sugarcane, and various fodder crops, of the effluent from sewage which had undergone bacterial treatment in a septic tank and filter beds. These experiments, and further experimentation, are important; because, if the bacterial method of purifying sewage is applied to the whole of Poona City and Cantonments, sewage effluent in large quantity will be available; and will be used as a source of manure supply, and for irrigation for land in the neighbourhood of Poona.

2. The purified sewage used in the experiments was, so to speak, artificially prepared. Nightsoil, urine, and water were mixed in such proportions as would probably exist in a water closet system, with a water-supply of 15 gallons per head per day; and then passed through a septic tank and bacteria beds. When thus treated, it gave an effluent which was practically clear, with a smell that was too faint to be noticed. Several samples were analysed by Dr. Leather, Agricultural Chemist to the Government of India; and the analyses showed that the purification was fairly complete, as the organic nitrogen was almost completely changed into nitrites. The test of complete purification is the conversion of the whole of the organic nitrogen into nitrates; but in any ordinary Indian soil nitrites are very quickly oxidized into nitrates. Nitrogen can only be taken up through the roots of any plants as nitrates; and it is only in this form that nitrogen existing in, or applied to, a soil can become immediately available as plant-food.

3. I have referred to these chemical changes, and to the manner in which nitrogen is taken up, through the roots, by *all* agricultural plants, because the President of the Poona Municipality has suggested that nitrogen in the form of nitrates, or nitrites, or ammonia salts, is not good for sugarcane, and some other crops. He supports his opinion with extracts from ancient literature, which, if published to-day, would be ridiculed by any English agriculturist of ordinary intelligence. Mr. Pudumjee, writing on the 2nd of January 1900, after he had got definitely-expressed opinions from Dr. Leather and myself, says:—

“Perhaps much depends on the form in which nitrogen is presented as food for sugarcane;” and again—

“The ridiculed books perhaps mean that free nitrogen, or nitrogenous manures that yield up nitrogen very easily, act injuriously, not on the plant itself (which grows up luxuriously on such manures, as is universally acknowledged), but upon its juice.”

Mr. Pudumjee here ignores, or refuses to believe, what he has been told regarding the *present* day knowledge of the relations which exist between the structural growth of agricultural plants, and nitrogen existing in combined forms in the soil, or in manure.

4. Experiments on sugarcane with various manures have been conducted for five years at Manjri; and it has there been conclusively proved that heavy crops of cane, yielding a high percentage of *gul* of good quality, *have* been produced by heavy applications of nitrogenous manures. Almost every description of manure available in India has been tried there; but Mr. Pudumjee does not apparently accept the Manjri experiments as conclusive. He contends that nitrites, nitrates, and ammonia salts affect the juice of cane so that it cannot be boiled down into solid *gul*. Such a result did *not* follow the use of nitrate of potash in the Manjri experiments; and Mr. Pudumjee offers the following explanation:—"One does not know what part the potash of the salt played in retarding the free and quick liberation of the nitrogen contained in the salt." This is mere speculation; the nitrogen was neither liberated quickly, nor freely; it was simply taken up by the plant as a nitrate; and probably in the form of nitrate of potash, the form in which it was applied as manure. A manure of this class is remarkably quick in its action, because the nitrogen, as well as the potash, are immediately available. A quick-acting manure has, if given in excessive quantity, a forcing action; and it may, in the case of sugarcane and fodder grasses, produce abnormal growth, and succulent watery stems, with a tendency for the crops to "lodge"; but every practical farmer knows these facts, and applies such manures, not in a heavy single dressing before planting, but in repeated top dressings, as required. The mere fact that the effluent contains nitrogen mostly as nitrites, clearly indicates that, as manure, it would act quickly; and, if used in excessive quantity at one time, it might have a forcing effect which would be injurious. One serious result in the case of sugarcane might then be anticipated, *viz.*, "lodging" of the crop. Dr. Leather has proved by analysis that canes which have "lodged" contain a lower percentage of sugar, and the *gul* from such canes contains a larger quantity of molasses, than upright canes of the same crop. Irrigation with the effluent may be considered as equivalent to top dressings of manure at very short intervals; and there can be no more economical way of applying manure.

5. The bacterial treatment of sewage not only converts the organic nitrogen into other, and more soluble, combinations, but probably also changes, to a considerable extent, the other constituents of manurial value which nightsoil contains. It is quite safe to assume that phosphates, or phosphoric acid, and potash, exist in the effluent in more soluble forms than in fresh nightsoil. It is also safe to assume that these constituents are in no part lost through bacterial action. We may further assume, without any misgiving, that an effluent which contains sufficient nitrogen (in any form) for the full requirements of sugarcane, or any other gross feeding crop, contains also all the phosphoric acid and potash which these crops will need. Other elements of plant-food need not be considered; because a manure obtains its commercial value from the proportions of nitrogen, phosphoric acid, and potash, which it contains; and by the combinations in which they exist.



6. The action of the bacteria, under similar conditions, is presumably independent of the quantity of sewage dealt with ; and it is probable that such an effluent can be used as freely as canal water, during the greater portion of the period of growth of such crops as require plenty of manure and much water. In the revised scheme for Poona, I understand that a macerating tank is to be substituted for the septic tank. Purification will, therefore, probably be somewhat less complete, and rather more work will be thrown on the land ; but any modifications in the application of the effluent to sugarcane will be determined by the further experiments now in progress at Manjri.

7. Purified sewage will, no doubt, be found to be best adapted to those crops which require plenty of manure and much water. The experiments concluded so far, have been with Sugarcane, Lucerne, Guinea grass, and certain Sorgums ; which, under liberal treatment, had been previously proved to be successful fodder crops in the Deccan. There are certain indigenous vegetables which can probably be grown successfully with effluent irrigation, such as surans, yams, alvi, &c. ; and experiments with these will be arranged for during the current season.

8. In the case of all the crops named, it will probably be found that a forcing manure, like the effluent, cannot be applied continuously during the *whole* period of growth. For instance, young Lucerne seedlings have very delicate tissues, and probably canal water would be more suitable for them than the effluent, during the first period of growth. Again, sugarcane, when newly planted, requires water at short intervals (every three or four days) for the first two or three weeks, in order to encourage the eyes to produce shoots ; and frequent effluent irrigation at this stage might prove harmful. Sugarcane makes slow progress when young, and it is probable that, if the effluent was applied regularly at this stage, it might prove too strong for the young plants. There was some indication of this in the experimental plot on the Kirkee farm. A green mould formed on the surface of the soil, and the plants became slightly unhealthy. The application of the effluent was stopped for three weeks, and one watering of canal water was given instead ; and the crop then became vigorous in growth, and exceedingly healthy in colour.

9. The quick-acting, and forcing character of the effluent must be recognised ; and it is not likely that it can be applied to any crop during the later period of its growth, whilst it is ripening, except in the case of Lucerne, and other fodder crops, which are cut green. Our former Manjri experiments proved that, in the case of sugarcane, the period of growth was extended by using manure in repeated top-dressings. The same result was observed at the Kirkee farm on the effluent plot, grown in comparison with two other plots irrigated with canal water, and manured respectively with heavy applications of *poudrette* and of farmyard manure. The cane in the effluent plot was a heavier crop, and "lodged" to a greater extent than in the other plots ; and it also

took longer to ripen. The *gul* was darker in colour, and contained slightly more molasses than that from the other plots. These facts point to the conclusion that the application of the effluent should be stopped in the case of the sugarcane, perhaps two or three months before the crop reaches maturity. This point will be specially investigated during the present season.

10. The "lodging" of the cane is in a great measure prevented, however heavy the crop may be, if the Mauritius system of planting is adopted. Details need not be given here; but no extra cost is involved; and this method of planting would probably be found to be specially suitable for an effluent farm.

11. It may be inferred from the foregoing paras. that such land as is taken up for the Poona effluent farm should be under the canal, because some additional pure water for irrigation may, from time to time, be necessary for the most profitable results; although the sewage may be fully sufficient for the area required. At the Matoonga farm, however, no extra water is used: but only fodder crops and vegetables are grown there.

12. It is probable that the effluent will show the most profitable results with Sugarcane and Lucerne. These crops, and such other crops as are likely to succeed under effluent irrigation, grow very well in medium black soil of moderate depth (two to three feet), with a substratum of murum. The combination of such a soil above, and porous murum below, secures natural drainage, which is an important consideration in the case of land that is to be continuously irrigated. A sufficient area of land of this class, in one block, can be got under the canal at Manjri, about 6 to 8 miles from Poona. In the monsoon, during heavy rain, effluent irrigation on such land would, however, be harmful; therefore, from time to time during the monsoon, the effluent must be diverted elsewhere. Light upland soil, even during heavy rainfall, could then be advantageously irrigated with the effluent; and I consider it necessary that a sufficient area of such land should be obtained, adjacent to the effluent farm proper. Crops which are grown on this sort of soil in the Poona District are generally poor, because they do not get enough monsoon rain; and because manure is very sparingly applied, if at all; but two or three waterings with the effluent, during the monsoon, would be of great advantage. If such light land is not provided, it would be necessary to turn the effluent into the river, so long as the sugarcane land was sodden and wet. This would, of course, be wasteful.

13. Experiments were conducted on the Kirkee farm to test, *on light land*, the effect of the effluent on various fodder crops. The crops which were selected had been thoroughly tested on the farm in previous years, on various descriptions of soils; and it had been proved that, as rain crops, they yielded heavily, matured quickly, and produced

excellent fodder, on almost any description of soil in good condition, in a favourable season. The fields were clean ; but only in moderate condition, as no manure had been applied during the previous two years. Two of these experimental crops (Lucerne and Guinea grass) are perennial ; one crop (maize), even when cut before maturity, has no particular tendency to produce new shoots from the roots, even if a considerable stubble is left ; therefore, a second crop (*utarli*) was grown after the maize, midway between the kharif and rabi seasons. This variety usually thrives well, if sown at this particular time. The other crops, *sundhia*, and *nilwa jowars*, and two American sorgums (Amber and Collier varieties), produced second cuttings from the root stocks of the first crops ; but better results would be got by ploughing up the land, and resowing after the first cutting ; and in this way three crops could be raised in the course of the year. The frequent cultivation of the same crop, on the same land, might induce unhealthy conditions ; but this difficulty could be overcome by practising "rotation" ; and various pulse crops, such as *wal*, *cholu*, *udid*, *mug*, &c., would be excellent for this purpose. These pulse crops would, I think, thrive under effluent irrigation ; and might be allowed to grow to maturity ; or the pods might be plucked early and sold as green vegetables, and the fodder cut green.

14. We have yet a lot to learn regarding the effect of purified sewage as a manure for Indian soils ; and also as regards the crops to which it can be most advantageously applied ; and this will require patient and thorough investigation by experiments. The effect of the effluent on several fodder crops, and its value as a manure, in comparison with heavy applications of poudrette, and of farmyard manure, are given in the attached Statements ; which also clearly show the plan of comparative experiment.

15. As already pointed out, experiments were conducted at the Kirkee farm to estimate the probable value of the effluent for sugarcane, in comparison with heavy applications of poudrette, and of farmyard manure. The opportunity was also taken to determine, as a side issue, whether crude nightsoil, or even the effluent, would produce such an effect on the crop that the juice could not be boiled down into solid *gul*. Eleven months after plantation, the poudrette, and farmyard manure plots showed indications of being ripe ; but the effluent and nightsoil plots were greener at this time. Trial boilings were, however, made. The cane from all the plots, but particularly from the nightsoil and effluent plots, yielded an unusually high percentage of juice to cane ; which was an indication that the crops were not fully matured. The poudrette and farmyard manure plots gave good, solid, bright-coloured *gul*. The effluent plot gave *gul* which got burnt and discoloured a few minutes before the boiling was complete. The nightsoil plot gave bright-coloured *gul* ; but it was somewhat soft, owing to a high percentage of molasses. Dr. Leather's Report on the samples of *gul*, and also of the soil before and after the crop had been grown, are attached.

16. Three weeks later, when the cane had been 12 months planted, and when the appearance of the crop in each plot indicated that all had reached maturity, *gul*-making was again proceeded with ; and *gul* of excellent quality was obtained from the poudrette, the farmyard manure, and the nightsoil plots. The blocks were all sold at Rs. 17/4 per pulla of 246 pounds. The blocks from the effluent plot were quite solid, but slightly darker in colour than the others ; and they sold for Rs. 16/12 per pulla.

17. At the time of the first boiling, a deputation of Municipal Commissioners, and others, inspected the operations ; and one member stated that maggots, or worms, would develop in the effluent *gul* then made. One block of this *gul* has been kept at the farm; but the anticipated development has not yet taken place, although two months have elapsed !

18. The nightsoil plot was an irregular area, bordering the comparative manure plots. There was no intention of determining the manurial effect of fresh nightsoil, and the experiment was only carried out to disprove the opinion quoted by the President ; therefore, its outturn results are not reported. The crop was, however, heavy.

19. The comparative manure results of the other plots have been tabulated, and are attached ; and the scheme of the experiment can be seen from the statement. It will be noticed that the slightly lower price of the effluent *gul* (solely due to its colour) was much more than made up by the extra quantity obtained, although a considerable quantity of this cane was "lodged." With the Mauritius system of planting, or by stopping the effluent at an earlier date, this lodging would probably have been much less ; and, consequently, the saccharine matter would have been more, as proved by Dr. Leather ; and the net money result might have been 10 per cent. higher than that from the poudrette cane, instead of only  $7\frac{1}{2}$  per cent ; so that the estimated return per acre, taken in my Note of last year, will probably be exceeded ; and it may, at least, be fairly taken as a *minimum* basis for calculating the farm revenue.

(Sd). J. A. MOLLISON,  
*Deputy Director of Agriculture.*

OFFICE OF AGRICULTURAL CHEMIST  
TO THE GOVERNMENT OF INDIA,  
DEHRA DUN, the 3rd. May 1900.

*Report on the composition of 4 samples of "gul", sent by  
the Deputy Director of Agriculture, Bombay.*

	276 1900 Gul from Poudrette Plot.	277 1900 Gul from Farm Manure Plot.	278 1900 Gul from Fresh Night- soil Plot.	279 1900 Gul from Effluent Plot.
Cane sugar, per cent....	70.75	70.55	62.22	69.60
Glucose, per cent. ...	16.12	15.85	23.13	17.53

These samples were taken on April 20th, at the time of the first of crushing of the sugarcane at Kirkee. As was observed at the time of crushing, the cane was immature on all the plots; and, although the "gul" was a nice colour in some cases, the percentage of sugar in the juice was found to be low. The composition of the samples of "gul" now affords evidence of a similar nature. The proportion of cane sugar is low, and the glucose is high, in all cases. The "gul," as usually produced at Poona, from ripe cane, contains about 75 per cent. of cane sugar and 10 to 12 per cent. of glucose. (*Vide* page 10 of Agricultural Ledger No. 19 of 1890.) Although the "gul" produced from the effluent plot is darker coloured than the others, its composition is *practically the same* as that from the poudrette plot.

(Sd.) J. WALTER LEATHER, P.H.D., F.I.C.,  
*Assistant Agricultural Chemist to the Government of India.*

No.  $\frac{88}{52}$

OFFICE OF AGRICULTURAL CHEMIST TO THE  
GOVERNMENT OF INDIA,

DEHRA DUN, *the 13th June 1900.*

*Report on the composition of 2 samples of soil, sent by the Sanitary Engineer, Poona, from the Kirkee Government Farm.*

	280/1900. Soil <i>Ex</i> Effluent Plot.	281/1900. Soil <i>Ex</i> land adjacent to Effluent Plot.
Organic matter and Combined water...	12.98	13.95
Nitrogen ... ..	.33	.025
Carbonate of Lime ... ..	6.32	7.73
Available Phosphoric Acid ... ..	.010	.009
Available Potash ... ..	.006	.009

There is no greater difference between these samples than one would expect from two pieces of land which had been treated differently. The sample 281 contained slightly less nitrogen and available phosphoric acid, but slightly more available potash, than the land which had been irrigated by the effluent and afterwards had borne a sugarcane crop. But the differences are only slight. The proportions of carbonate of lime have nothing to do with the effluent, and represent inherent differences in the land. The difference in the proportions of organic matter and combined water are also probably due to this cause.

(Sd.) J. WALTER LEATHER,  
*Assistant Agricultural Chemist to the Government of India,*

*Extract from paragraph 4 of the Report of the Director of Land Records and Agriculture, Central Provinces, No. 1783-89A, dated 29th August 1899.*

“In the West Indies, and in the Mauritius, large quantities of guano, nitrophosphates, and other mineral and artificial manures, are used for sugarcane. This is applied to the plants after they have made considerable progress in their growth.”

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*Extract from page 217 of the “Dictionary of Economic Products of India,” Vol. VI-Part II.*

“Bones are not used, and this is one of the most melancholy features of Indian agriculture. It is especially to be regretted with regard to sugarcane cultivation; which, more than any other crop, requires a supply of phosphatic manure. The use of bones, as manure, will have to encounter the strongest opposition; but no opposition, or prejudice, could be greater than that manifested against the use of poudrette. PROFESSOR COOKE has patented a manure made chiefly of bones, but he has not yet followed up the experimental success which he secured. Crushed bones, *i.e.*, crushed by hand labour, would amply repay the cost. It is not necessary to dissolve bones with sulphuric acid, or in other ways.”

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*Extracts from pages 175 and 177 of the “Dictionary of Economic Products of India,” Vol. V.*

“(6). *Ammoniacal Liquor*.—The ammoniacal liquor of gas works is another good manure which ought to be utilised wherever available. Of course, in India, this is only so in the neighbourhood of a few large towns; but there, it is specially applicable, as it is invaluable to the market gardener for the cultivation of vegetables.”

“(3) *Nitrates*.—The nitrates of potash and soda are both employed as manures in Europe, principally on account of the nitrogen they contain, although nitrate of potash is valuable also from the potash that it can supply to the plants.”

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*Extract from page 29 of the Agricultural Ledger No. 8 (1897).*

“The large out-turn from plot 11 (sugarcane) is possibly due to the nitrogen in the superphosphate being in a more readily available form. It will be observed that from bones, the lowest out-turn is obtained; then a larger out-turn is obtained from bones and saltpetre, and bone superphosphate—both containing more readily available nitrogen than in the bones alone; and the highest yield is obtained from the dissolved bones and saltpetre, in which the amount of readily available nitrogen was the highest. In any case, the large amount of phosphoric acid has not shown itself of any advantage.”

*Extract paragraph 15, page 7, of the Agricultural Ledger No. 8 of 1893.*

“It has been proved by the Manjri experiments, which will be referred to in detail further on, that certain manures are more active and effective for sugarcane than others ; and that, apparently, the most important constituent of manures for sugarcane is nitrogen, in immediately available condition. The experiments clearly indicated, if they did not absolutely prove, that nitrogen in this form was absolutely essential to feed the young shoots during the early stages of growth. The sugarcane “set” itself contains very little on which the young shoot can feed. Therefore, in the case of land in low condition, the manures to be applied before plantation should be such as are known to be quick-acting ; as, for instance, poudrette, fish manure, and the various country-made oil cakes. Farmyard manure, (which has the reputation of acting slowly), if used, should be thoroughly decayed before application. In this condition it will probably act more effectively, and, quickly.”

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*Extract from paragraph 133 of Dr. Voelcker's Report on the  
“Improvement of Indian Agriculture” (Page 111).*

“Nitre, or saltpetre (nitrate of potash), is a salt with which the soil in many parts of India is impregnated, and the manufacture of nitre, together with some common salt, by a somewhat crude process of extraction and purification, may be seen very frequently. Though the manufacture is widely distributed, it is in Behar, and the North-West Provinces, that most nitre is made. The earth around the remains of old villages is specially found to be thus impregnated. The accumulations of the salt, in all probability, have their origin in the natural process of nitrification (production of nitrates), which the solid and liquid excreta of cattle and men, as well as vegetable and other refuse, have undergone. Wood, and other vegetable ashes, supply potash in the form of carbonate of potash ; which then combines with the nitrates, producing nitrate of potash. The potash in the soil itself, more especially when the soil is clayey in nature, no doubt contributes also to the production of nitre.”

*Comparative manure experiments with sugarcane.*

Manure.	Date of Gul making.	Weight of cane per acre.	Weight of juice per acre.	Percentage of juice to cane.	Weight of Gul per acre.	Percentage of Gul to cane.	Cost of cultivation per acre.	Gross value of outturn per acre.	Net return per acre.	REMARKS.
		lbs.					Rs. a.	Rs.	Rs. a.	
21 waterings with effluent—equal to approximately 26 inches of rainfall.	16th to 21st April; and 8th to 11th May.	94,160	68,184	72·4	9,576	10·1	268 12	652	383 4	Irrigated with effluent : 3 times in June, 4 times in July, once in August, twice in November, and 4 times in December 1899 ; 4 times in January, and 3 times in February 1900. Got also canal water as required during the earlier and later periods of growth.
25 tons of farm yard manure per acre.	18th to 21st April; and 8th to 10th May.	79,764	57,624	72·2	8,304	10·4	348 15	582	234 1	Irrigated 35 times during the year with canal water.
25 tons of poudrette per acre.	18th to 21st of April; and 8th to 10th May.	78,540	58,056	73·9	8,752	11·1	453 0	607	254 -0	Do. do. do.

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J. A. MOLLISON,  
*Deputy Director of Agriculture.*



## I.—SERIES OF PLOTS.

*Comparative Manure and Irrigation experiments with various Fodder Crops, all sown, or planted, on 8th May, 1899, except Utarli, which was sown on 22nd August.*

Manure.	Crop.	Date of harvesting.	Outturn per acre at each cutting.	Total per acre outturn.	Cost of cultivation per acre.	Value of Outturn per acre.	Net return per acre.	REMARKS.
Irrigated 21 times with effluent, the irrigation being approximately equal to 23 inches of Rainfall.	Guinea grass...	30th June 1899...	6,160	56,308	Rs. a. 121 0	Rs. a. 375 6	Rs. a. 254 6	<p>Fodder valued at 150 lbs. per rupee, and readily saleable at that price in Poona. The crop was irrigated with effluent 4 times before the 2nd cutting. No effluent was given between the 1st of August and the 12th November. Plague was prevalent in Poona City, and cases occurred at the farm; and, as a precautionary measure, the carting of effluent from Poona City was stopped temporarily. Two waterings with effluent were given in November 1899, two in December 1899, three in January 1900, three in February, three in March, and four in April 1900. Canal water was given when the effluent was stopped. It will be noticed that the crop responded with a good outturn, to the liberal application of effluent in the hot weather.</p> <p>Fodder valued at 200 lbs. per rupee. Easily saleable in Poona at 100 to 150 lbs. per rupee retail. The outturn results are extremely satisfactory, and there can be no doubt that the effluent is particularly suitable for Lucern. The crop got blighted in April and May 1900, like the other comparative Lucern plots; hence the diminished outturn then. Effluent was given four times before the 2nd cutting. It was with-held, for reasons given above, from 6th August to 11th November. Two waterings were given in November, two in December 1899; and the effect of these applications is clearly indicated by the increased outturn in the subsequent cuttings. Effluent was applied three times in January, three times in February, three times in March and four times in April 1900. Canal water was given, as required, when the effluent was stopped.</p>
		5th Aug. 1899...	7,868					
		2nd Sep. 1899...	6,216					
		1st Oct. 1899...	7,336					
		9th Nov. 1899...	3,780					
		24th Dec. 1899...	3,976					
		17th Feb. 1900...	5,600					
		23rd Mar. 1900...	6,720					
	18th Apr. 1900...	8,652						
	Lucern	19th July 1899...	4,564	1,02,088	Rs. a. 173 11	Rs. a. 510 7	Rs. a. 336 12	
		7th Aug. 1899...	9,576					
		3rd Sept. 1899...	7,364					
		30th Sept. 1899...	7,952					
		24th Oct. 1899...	6,720					
		21st Nov. 1899...	5,964					
		25th Dec. 1899...	8,680					
		30th Jan. 1900...	12,992					
		3rd Mar. 1900...	12,152					
		23rd Mar. 1900...	9,520					
		14th Apr. 1900...	8,652					
2nd May 1900...		7,952						

Irrigated four times with the effluent; the irrigation being approximately equal to 4 inches of rainfall.

Sundhia Jowar. {	30th June 1899...	22,316	} 32,480 {	(13 10)	(89 4)	(72 10)	<p>This fodder is valued at 250 lbs. per rupee, but would probably be easily saleable at a dearer rate. Stalks very long and very fine. Cut in full flower 53 days after sowing. The 2nd crop from the stubble shows that it would be better to sow fresh seed each time. Three to four crops could be got in the year.</p> <p>Stalks coarser than Sundhia, and not worth so much as fodder; valued at 300 lbs. per rupee. Took 88 days between seed time and harvest. Cut when in flower. Three crops at most would be got in a year.</p> <p>An excellent fodder, equal in value at least to Nilwa, and matures quickly. Cut 66 days after sowing. Valued at 300 lbs. per rupee. This fodder is very sweet, and has much leaf growth; second crop satisfactory, but a fresh sowing each time would be better; and three crops could easily be got in the year.</p> <p>Was reaped 71 days after sowing. Other remarks as for the Amber variety.</p> <p>The Maize was a very heavy crop, which was reaped 66 days after sowing. Stalks very coarse, fodder valued at 400 lbs. per rupee, and doubtful whether it would be readily saleable at that price.</p> <p>The Utarli, owing to the abnormal character of the season, got blighted, and was a poor crop; and the cost of cultivation of this crop exceeded the value of the out-turn.</p>
	30th Aug. 1899...	10,164		31 15	129 14	97 15	
Nilwa Jowar ... {	4th Aug. 1899...	32,536	} 44,716 {	(22 0)	(108 7)	(86 7)	
	16th Oct. 1899...	12,180		38 12	149 0	110 4	
American Sorghum, Amber variety. {	13th July 1899...	36,764	} 55,132 {	(18 8)	(122 8)	(104 0)	
	23rd Sept. 1899...	18,368		34 0	183 12	149 12	
American Sorghum, Collier variety. {	18th July 1899...	34,188	} 54,740 {	(21 2)	(114 0)	(92 14)	
	25th Sept. 1899...	20,522		40 1	182 8	142 7	
Utarli ... ..	15th July 1899...	51,576	} 59,192 {	(27 9)	(129 0)	(101 7)	
Maize ... ..	8th Nov. 1899...	7,616		64 1	154 5	90 4	

J. A. MOLLISON,  
Deputy Director of Agriculture.

## II.—SERIES OF PLOTS.

*Comparative manure and irrigation experiments with various fodder crops, all sown or planted on 8th May 1899, except Utauli, which was sown on 22nd August 1899.*

Manure.	Crop.	Date of harvesting.	Per acre Out-turn each cutting.	Total per acre Out-turn.	Cost of cultivation per acre.	Value of Out-turn per acre.	Net return per acre.	REMARKS.	
manure per acre, all applied before plantation. water regularly.	Guinea grass ...	1st July 1899 ...	lbs. 3,752	} 28,532	Rs. a. 155 5	Rs. a. 190 4	Rs. a. 34 15	<p>Irrigated 38 times with canal water; natural rainfall deficient, and crop did not do as well as usual during the monsoon. Cuttings very poor in the hot weather. The plot is a striking contrast to the effluent plot throughout the year, and especially so in the hot weather.</p>	
		5th Aug. 1899 ...	5,432						
		2nd Sept. 1899 ...	4,788						
		1st Oct. 1899 ...	6,216						
		9th Nov. 1899 ...	3,220						
		24th Dec. 1899 ...	1,400						
		18th Feb. 1900 ...	1,402						
		23rd Mar. 1900 ...	1,062						
	19th Apr. 1900 ...	1,260							
	Lucerne ...	19th July 1899 ...	3,472	} 74,620	257 13	373 2	115 5		<p>Irrigated 38 times with canal water; oftener than usual, owing to the scanty rainfall. Crop not equal to either the effluent, or the poudrette manured crop; but a full average crop for the Poona District. Blight appeared to some extent in this plot, and also in the other Lucerne plots under experiment, in April and May 1900.</p>
		7th Aug. 1899 ...	8,036						
		3rd Sept. 1899 ...	6,440						
		30th Sept. 1899 ...	7,980						
		24th Oct. 1899 ...	7,168						
		21st Nov. 1899 ...	6,272						
		25th Dec. 1899 ...	8,064						
		30th Jan. 1900 ...	8,680						
		3rd Mar. 1900 ...	6,776						
		23rd Mar. 1900 ...	5,320						
		14th Apr. 1900 ...	4,172						
2nd May 1900 ...		2,240							

Each plot manured with 20 tons farm yard Irrigated with canal	Sundhai Jowar.	4th July 1899 ...	12,992	} 18,816	62 6	75 4	12 14
		31st Aug. 1899...	5,824				
	Nilwa Jowar ...	6th Aug. 1899 ...	19,348	} 25,648	68 13	85 7	16 10
		15th Oct. 1899 ...	6,300				
	American Sor- ghum, Amber variety.	22nd July 1899...	20,580	} 32,480	67 1	108 4	41 3
		30th Sept. 1899...	11,900				
	American Sor- ghum, Collier	25th July 1899 ...	16,688	} 29,148	67 15	97 2	29 3
		30th Sept. 1899...	12,460				
	Maize ... ..	17th July 1899 ...	17,724	} 25,424	96 2	69 15	.....
	Utarli ... ..	8th Nov. 1899 ...	7,700				

A heavy dressing of farmyard manure, with canal irrigation, gave comparatively poor results. The plot on which Utarli followed Maize, was cultivated at a loss. The Utarli was, however, blighted; owing to the abnormal character of the season.

J. A. MOLLISON,  
Deputy Director of Agriculture.

### III.—SERIES OF PLOTS.

*Comparative manure and irrigation experiments with various fodder crops; all sown, or planted, on 8th May; except Ularli, which was sown on 22nd August.*

Manure.	Crop.	Date of harvesting.	Per acre Out-turn, each cutting.	Per acre total Out-turn.	Cost of cultivation per acre.	Value of Out-turn per acre.	Net return per acre.	REMARKS.	
Manure, all applied before plantation. Irrigated water regularly.	Guinea grass ...	2nd July 1899...	5,040	39,900	276 10	266 0	.....	Irrigated 38 times with canal water. The heavy application of poudrette was very costly: hence the cost of cultivation exceeds the value of the out-turn. The season was abnormal; with more rain, the crop would have thriven better. The yield rapidly declined, as usual, in the hot weather. The effluent plot, however, maintained its yield at this season; and the comparative plots were a striking contrast.	
		5th Aug. 1899...	9,464						
		3rd Sept. 1899...	9,128						
		1st Oct. 1899...	7,280						
		9th Nov. 1899...	3,500						
		24th Dec. 1899...	1,456						
		18th Feb. 1900...	1,260						
		23rd Mar. 1900...	1,120						
		19th Apr. 1900...	1,652						
		Lucerne ...	19th July 1899...						6,188
	7th Aug. 1899...		12,096						
	3rd Sept. 1899...		8,848						
	30th " 1899...		9,940						
	25th Oct. 1899...		8,232						
	21st Nov. 1899...		8,260						
	25th Dec. 1899...		9,884						
	30th Jan. 1900...		10,248						
	3rd Mar. 1900...		8,484						
	23rd " 1900...		6,020						
	14th Apr. 1900...	5,180							
2nd May 1900...	2,800								

Each plot manured with 20 tons of poudrette per with canal	Sundhia Jowar	7th July 1899..	21,980	} 30,912	190	5	123	10	.....
		31st Aug. 1899..	8,932						
	Nilwa Jowar	5th Aug. 1899..	32,760	} 42,056	197	0	140	2	.....
		12th Oct. 1899..	9,296						
	American Sorghum	21st July 1899..	34,076	} 52,164	193	13	173	14	.....
	Amber variety ...	27th Sept. 1899..	18,088						
	American Sorghum	24th July 1899 .	33,460	} 52,192	194	2	173	15	... ..
	Collier variety ...	28th Sept. 1899...	18,732						
	Maize	... 16th July 1899...	35,070	} 44,058	220	8	117	10	.....
	Utarli.	... 9th Nov. 1899..	8,988						

These figures show that in no case are the out-turn results so good as in the effluent plots. The effect of the poudrette was, of course, not nearly exhausted by the first crops, and the 2nd cuttings. The intention was to take three or four crops under irrigation during the year: hence the heavy application of poudrette. The abnormal character of the season made this impossible. The cold weather crops got blighted on each series of plots so badly that they were grubbed up. The hot weather crops were also blighted: a result very common this year through the whole Presidency.

J. A. MOLLISON,  
Deputy Director of Agriculture.

## APPENDIX C.

## Poona Sewerage Scheme.

## GENERAL ABSTRACT.

Plan No.	Estimate No.	Items.	Amounts.
1-11	1	Laying Stoneware Pipe, and Moulded Cement Concrete sewers ... ..	4,84,971
12	2	964 Ordinary Manholes ... ..	98,485
13	3	105 Flushing Manholes ... ..	12,607
13	4	48 Automatic Flushing Tanks ... ..	20,815
14	5	1 Do. of 6000 gallons, for Sewage ... ..	2,092
15	6	Erecting 48 five-inch Fresh Air Inlet Shafts ... ..	912
1	7	Cast Iron Pipes for the Sewage Mains, including laying ... ..	6,760
1	8	Cast Iron Pipes for the Air Mains, including laying ... ..	10,809
16	9	Constructing 4 Ejector Stations ... ..	9,472
16	9	Machinery, Ejectors, Inlet Shafts, &c., complete... ..	1,70,680
3-11	10	Covering Stoneware Pipe Sewers below 15ft. depths with cement concrete ... ..	7,671
17	11	Converting existing Public Privies into Double Row Shoot and Trough Latrines ... ..	16,360
17	12	Constructing 50 new Public Latrines of 10 seats in each ... ..	35,000
18-19	13	House Connections ... ..	1,95,000
<i>Four-fifths of the cost of:—</i>			
20	14	a—Engine House ... ..	28,614
21-22	15	b—Chimney Shaft and Economiser ... ..	7,078
	16	c—Engines and Pumping Machinery complete ... ..	2,32,000
23	17	d—Balancing Tank Sewer, and Emergency Outlet ... ..	26,731
24	18	e—Engineer's Quarters ... ..	5,259
25	19	f—Outhouses for Do. ... ..	2,444
26	20	g—Engine Driver's Quarters ... ..	2,063
27	21	h—Barrack for Firemen, Oilers, &c. ... ..	5,812
28	22	i—Constructing a Macerating Tank on the Rising Main ... ..	81,955
28-33	23	j—Steel Rising Main ... ..	4,00,000
	24	k—Land Compensation for Pumping Station, &c. ... ..	6,400
Total ...			18,69,990
<i>Add</i>			
Establishment, and Tools and Plant, at 4 per cent ...			74,800
Contingencies, at 5 per cent ... ..			93,499
Cost of land for Effluent Farm ... ..			4,00,000
Buildings, &c., for Do. ... ..			20,000
Working Capital for Do. ... ..			60,000
Grand Total ...			25,18,289
Conversion of Privies into W. C's. ... ..			4,54,223

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of the Sanitary Board.

## APPENDIX D.

## Poona Sewerage.

## PROBABLE PERIODS OF EXPENDITURE.

Year.	Amount in thousands of rupees.
<i>1st Year.</i>	Rs.
Establishment, and Tools and Plant ... ..	30
Machinery ... ..	215
Stoneware Pipes ... ..	228
Manholes, and Flushing Tanks (fittings, &c.) ... ..	68
Sewage and Air Mains ... ..	16
Steel Main ... ..	225
House Connections (fittings, &c.) ... ..	130
Laying Sewers ... ..	50
Engine House and Quarters ... ..	20
Balancing Tank Sewer ... ..	12
Land Compensation ... ..	6
Total ... ..	10,00
<i>2nd Year.</i>	
Establishment, and Tools and Plant ... ..	25
Machinery ... ..	150
Fire-bricks, and Fire-clay ... ..	5
Chimney and Economiser ... ..	2
W. C. Fittings ... ..	310
Public Latrine do. ... ..	13
Steel Main ... ..	150
Manholes, and Flushing Tanks ... ..	37
Sewage and Air Mains ... ..	2
Ejector Stations ... ..	9
House Connections ... ..	40
Effluent Farm ... ..	400
Engine House, and Quarters ... ..	20
Macerating Tank ... ..	32
Carried over ... ..	11,95



## APPENDIX D.—concl'd.

Year.	Amount in thousands of Rupees.
Brought forward ...	11,95
<i>2nd Year.—contd.</i>	
Balancing Tank Sewer ... ..	15
Laying Sewers ... ..	150
Contingencies... ..	40
Total ... ..	14,00
<i>3rd Year.</i>	
Establishment, and Tools and Plant ... ..	20
Machinery ... ..	38
Laying Sewers ... ..	65
Manholes, and Flushing Tanks ... ..	29
House Connections ... ..	25
Public Latrines ... ..	38
Engine House, and Quarters ... ..	4
Laying Steel Main ... ..	25
Construction of Water Closets ... ..	144
Macerating Tank ... ..	50
Working Capital for Farm ... ..	60
Farm Buildings ... ..	20
Contingencies ... ..	54
	5,72

*Recapitulation.*

Year.	Amount.
	Rs.
1st year ... ..	10,00,000.
2nd „ ... ..	14,00,000.
3rd „ ... ..	5,72,000.
Total ... ..	29,72,000.

Of which, about 18½ lakhs will be for English materials and fittings.

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## APPENDIX E.

## Poona City Water Supply Improvements.

## GENERAL ABSTRACT.

Plan No.	Estimate No.	Items.	Amounts.
			Rs.
2	1	Continuous Flow Settling Tank ... ..	2,13,687
3	2	High Level Reservoirs, with Foundation Blocks for Engines and Pumps in one of the two Towers, and a separate Boiler House ... ..	74,254
	3	Engines and Pumps—Machinery complete, with W. I. Chimney Shaft ... ..	88,000
4	4	Additions and Alterations to the two existing circular Settling Tanks, for converting them into Sumpths; and the 18" Stoneware Pipe Inlet from the new Settling Tank ... ..	20,375
5	5	Engine Driver's Quarters ... ..	3,155
6	6	Barrack for Firemen, Oilers, &c. ... ..	4,018
1	7	Cast Iron Pipes for the new Mains, as per statement E.	2,75,563
1	8	Sluice Valves for the new Mains, as per statement F ...	10,787
1	9	Fire Hydrants for the new Mains, as per statement G ...	3,220
1	10	Removing, and relaying in other positions, portions of the existing pipes, <i>vide</i> statement C ... ..	18,750
7-9	11	Horizontal Pipe Services, to be substituted for the existing Dipping Cisterns, <i>vide</i> Statement H. ... ..	13,457
10	12	Providing New Cattle Troughs, <i>vide</i> Statement J. ...	8,925
		Total ...	7,34,191
		<i>Add</i>	
		Contingencies at 5 per cent. ... ..	36,709
		Land Compensation ... ..	9,100
		Grand Total ...	7,80,000

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## APPENDIX F.

## Poona Water Supply Improvements.

## PROBABLE PERIODS OF EXPENDITURE.

Year.	Amounts in Thousands of rupees.
<i>1st Year.</i>	Rs.
Settling Tank ... ..	124
High Level Tanks, &c ... ..	68
Machinery, &c, ... ..	80
Altering old Circular Tanks ... ..	20
Quarters for Engine Room Staff... ..	3
Cast Iron Pipes ... ..	256
Sluice Valves ... ..	10
Hydrants ... ..	3
Pipe Services ... ..	7
Cattle Troughs ... ..	4
Contingencies ... ..	16
Land Compensation ... ..	9
Total ...	600
<i>2nd Year.</i>	
Settling Tank ... ..	90
High Level Tanks, &c. ... ..	6
Machinery, &c. ... ..	8
Quarters for Engine Room Staff ... ..	4
Cast Iron Pipes ... ..	20
Sluice Valves and Hydrants ... ..	1
Removing, and relaying, existing pipes ... ..	19
Pipe Services ... ..	7
Cattle Troughs ... ..	5
Contingencies ... ..	20
Total ...	180

## RECAPITULATION.

Year.	Amount Rupees.
1st Year ... ..	6,00,000
2nd ,, ... ..	1,80,000
Total Rs. ...	7,80,000

Of which, about 4½ lakhs will be for English materials and fittings.

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## APPENDIX G.

## Effluent Farm.

<i>NET REVENUE.</i>	Rs.
See para. 33 <i>ante</i> , and Mr. Mollison's Note, Appendix B of my former Address; and also his second Note and Statements, Appendix B of this (second) Address.	
<i>1st Year.</i>	
275 Acres Sugarcane, at Rs. 300 ... ..	82,500
100 Acres Lucerne, at Rs. 300 ... ..	30,000
300 Acres Fodder Crops, under the Canal, 3 crops in the year; at Rs. 200 ... ..	60,000
600 Acres Fodder Crops on the high land, only during the monsoon: at Rs. 70 ... ..	42,000
Total ...	2,14,500
<i>2nd Year.</i>	
As above ... ..	2,14,500
275 Acres extra, Sugarcane, at Rs. 300 ... ..	82,500
Total ...	2,97,000
<b>FARM PERMANENT ESTABLISHMENT.</b>	
Manager, at Rs. 350 per month (para. 72) ... ..	4,200
Pension Fund for ditto, at Rs. 55 ditto ... ..	660
Clerk and Accountant, at Rs. 35 ditto ... ..	420
Overseer at Rs. 50 ditto ... ..	600
Contingencies, at Rs. 10 ditto ... ..	120
Total ...	6,000

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**APPENDIX H.**  
**Loans Required.**

SEWERAGE.

	Rs.
<i>1st Year—</i>	
Works ... ..	10,00,000
Total...	10,00,000
<i>2nd Year—</i>	
Works ... ..	14,00,000
Interest at 5 per cent. and Sinking Fund for 30 years, on about three-fourths of the 1st year's expenditure ... ..	50,000
Total...	14,50,000
<i>3rd Year—</i>	
Works ... ..	5,72,000
Interest and Sinking Fund on 1st year's expenditure ... ..	65,000
Do. do. on about three-fourths of 2nd year's expenditure ... ..	83,000
Total...	7,20,000
<i>4th Year—</i>	
Interest and Sinking Fund on total of 3 years ... ..	2,06,000
<hr/> WATER SUPPLY,	
<i>1st Year—</i>	
Works ... ..	6,00,000
Total...	6,00,000
<i>2nd Year—</i>	
Works ... ..	1,80,000
Interest at 5 per cent. and Sinking Fund for 20 years, on about two-thirds of the 1st year's expenditure... ..	40,000
Total...	2,20,000
<i>3rd Year—</i>	
Interest and Sinking Fund on above totals ... ..	66,000
Charge for extra water (para. 96) ... ..	25,000
Total...	91,000
<i>4th Year—</i>	
Interest and Sinking Fund on above totals ... ..	75,300
Charge for extra water ... ..	25,000
Total...	1,00,300

## APPENDIX H.—concl.

## RECAPITULATION.

Year.	Works only.	Including Interest and Sinking Fund.
	Rs.	Rs.
<b>1st Year.—</b>		
Sewerage ... ..	10,00,000	10,00,000
Water-supply ... ..	6,00,000	6,00,000
<b>2nd Year.—</b>		
Sewerage ... ..	14,00,000	14,50,000
Water-supply ... ..	1,80,000	2,20,000
<b>3rd Year.—</b>		
Sewerage ... ..	5,72,000	7,20,000
Water-supply ... ..	.....	91,000
<b>4th Year.—</b>		
Sewerage ... ..	... ..	2,06,000
Water-supply ... ..	.....	1,00,300
<b>5th Year.—</b>		
Interest at 5 per cent., and Sinking Fund for 25 years, on Rs. 92,437; being the estimated deficit at end of 5th year ... ..	.....	6,559
Grand Total... Rs.	37,52,000	43,93,859

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## APPENDIX I.

## Profit and Loss.

AFTER THE 4TH YEAR.

<i>Debit of 5th Year—</i>	Rs.
Interest and Sinking Fund on total of Sewerage, including Interest and Sinking Fund to end of 4th year (Rs. 33,76,000)...	2,19,609
Interest and Sinking Fund on total of Water-supply, including Interest and Sinking Fund to end of 4th year, (Rs. 10,11,000) .	81,123
Extra Interest and Sinking Fund on cost of Sewage Pumping machinery; to renew it in 20, instead of 30 years ; (para. 43)...	6,000
Working expenses of Sewerage ; (paras. 36, 38 and 72) .. ...	49,000
Working expenses of Water-supply ; (para. 89) ... ..	7,000
Extra cost of water (para. 96) ... ..	25,000
Total ...	3,87,732
 <i>Credit of 5th Year—</i>	
Net Revenue from farm in 1st year ... ..	2,14,500
Saving of loss on present poudrette system ... ..	40,000
X Yearly charge for water closets ... ..	36,795
Saving of cost of the present Water-supply system ... ..	4,000
Total ...	2,95,295
<i>Net loss</i> ...	92,437
 SUBSEQUENT YEARS. 	
<i>Yearly debit—</i>	
As for 5th year ... ..	3,83,399
Interest and Sinking Fund on Rs. 6,559, added at end of 5th year ... ..	465
Interest and Sinking Fund on deficit of 5th year (Rs. 92,437) ...	6,559
Total ...	3,90,023
 <i>Yearly credit—</i>	
As for 5th year ... ..	2,95,295
Net profit on 275 extra acres of sugarcane ... ..	82,500
Total ...	3,77,795
Final extra taxation required after the 5th year ... ..	12,228

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