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An information system for village handpumps

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Abstract. The need for a computerised information system for handpumps installed in any state is brought out. A system with organisational and software aspects is presented. The organisational aspect covers the generation and transmission of data on handpumps at the users' and the government level. The software consists of a Fortran program, data files, an updating program and a transaction file. The periodic updating of data files is discussed. The system output covers many items of vital information needed for formulating maintenance and research and development policies. A test run of the program with an arbitrarily selected data base is discussed.

Keywords. Drinking water; handpumps; information system; maintenance scheduling; modes of failure; reliability.

1. Introduction

The traditional sources of drinking water for Indian villages have been tanks, open dug wells and streams. Though villages must have been originally founded at locations where water was easily available, drinking water would become scarce with the passage of time due to *e.g.* increased upstream use of groundwater and streams, silting and breaching of tanks, progressive pollution of the water source etc. This has resulted in a situation where the population of thousands of villages in Karnataka alone, for example, does not have easily accessible drinking water sources, especially during the summer.

The handpump programme was launched by many state governments to remedy this serious situation. There are now (June 1983) about 51,300 borewells in the 27,000 villages of Karnataka, each fitted with a handpump. The borewells have depths upto 75 m, and a diameter of 150 mm (the older ones have a lower diameter), and penetrate into crystalline rock which is found on an average 15 m below ground almost throughout Karnataka. The borewells, therefore, tap the water found in the fractures and fissures within such rock. At the present rate of withdrawal, this water is unlikely to be ever exhausted nor does it flow away since the fractures and fissures are not all interconnected. Thus the borewell can yield water throughout the year unlike most dug wells which tap only the water table aquifer above the rock.

However, year-round water supply for rural domestic consumption is still a goal that remains to be achieved since handpumps break down at a rate which is too high for the concerned maintenance organizations to cope with. Some time ago (when there were 30,000 handpumps in the State), the mean time between a repair and a subsequent failure of a given pump was estimated to be 20 weeks (Rama Prasad 1979), which would require a maintenance capability of 1500 repairs per week to keep all the pumps in the state working (the actual maintenance capability at that time was 550 repairs per week). The maintenance capability has increased now. Moreover, pumps conforming to a design standard of the Indian Standards Institution (ISI 1981), which are estimated to have a mean time of about 36 weeks from repair to failure (Gray 1982), are being installed in all new borewells for the past two years. Even so, a considerable proportion of handpumps are out of order at any given time.

2. Need for an information system

The handpumps in Karnataka are scattered over an area of about 1,90,000 km^2, larger than many nations of the world. The administration in regard to the maintenance of the pumps is, therefore, carried out at many levels. At the top is the chief engineer. The State is divided into several divisions, each of which is headed by an executive engineer. Each division extends over two or three districts, and consists in turn, of several subdivisions. An assistant executive engineer is in charge of each subdivision, which has jurisdiction over four to five or even more taluks. At almost each taluk, a junior engineer and a mechanic are stationed, with a jurisdiction of about 200 handpumps. In addition, each subdivision has a mobile maintenance unit, which consists of a truck, its driver and mechanics. The failure of a handpump is communicated by its users to the junior engineer at the taluk or to the subdivision. The repair is then carried out either by the taluk-level mechanic or the mobile unit.

With such a far-flung system, it is not easy to keep track of the number of handpumps out of order, the mean time to failure (MTTF) or between failures (MTBF), the parts which fail often (the 'modes' of failure) and other information needed to decide the direction in which work to improve the handpump should proceed, the maintenance schedule, the strength of the maintenance team, budgeting etc. Some of the information is needed periodically, *e.g.*, every week or fortnight. For instance, information on the location of pumps throughout the State which are out of order is needed every week for planning the repair schedule during the coming weeks. Any information system devised should, therefore, be capable of giving such information at the desired intervals at relatively small expense of effort and money.

3. Objective

The objective of the present work was to develop an information system capable of giving all information needed about the handpumps in a given administrative unit (*e.g.*, a taluk) as often as necessary.

4. Methodology

4.1 *The system framework*

Each subdivision, which is the lowest administrative unit having secretarial staff, has 2000 pumps or more under its jurisdiction. With new installations, repairs or failures occurring every week, a very large number of computations have to be made every week, involving all the 2000-odd pumps to arrive at the current MTTF, MTBF, modes of failure, maintenance schedule etc. Unlike many other information systems, far more complex tasks are involved here than mere information retrieval. A manual system for the task would be much more expensive, slower and need more space than a computerised system, besides being prone to error. It was, therefore, decided to develop a computerised information system.

The system developed here consists of a data base on handpumps in the State, a main program to process the data, an updating program to keep the data up to date and a transaction file on which the updating program operates. The data is updated each time a new pump is installed, a pump failure is reported or a pump is repaired, by preparing a transaction file containing the new information and running the updating program. The main program is executed to process the data whenever required. The data can be stored on punched cards, paper tape, magnetic tape or disc as the case may be. The same is true of the main program as well as the updating program. The organization of storage differs according to the storage device. The system described in this paper assumes disk storage, but this does not take away the generality of the system.

The government agency which implements the handpump programme (the Public Health Engineering Division, or PHE for short, in Karnataka) is at the centre of the information system. It is the point to which information from the field flows. It, in turn, transmits the information to the computer installation and receives the output from the computer, on the basis of which it formulates its policies and programmes of action.

4.2 *Data input*

When implementing the system for the first time, the data base is prepared with all the villages and existing pumps included. This data is updated whenever one or more of the three following events happen. (i) A new pump is installed: A new pump is usually installed by the manufacturer in the presence of an engineer of the subdivision in whose jurisdiction the borewell lies. The assistant executive engineer in charge of the subdivision, therefore, sends to the information cell whenever a new pump is installed, information on the date of installation, make of pump and pump identification (*e.g.*, name of the village). (ii) A pump goes out of order: When this happens, its users report the matter either to the junior engineer or mechanic-cum-supervisor stationed in the taluk town concerned, or directly to the PHE subdivision office, if it is near enough. In either case, the assistant executive engineer is again the officer who communicates to the information cell the pump identification and the date of failure. (iii) A pump is repaired: A repair is carried out either by the engineer and the mechanic stationed at the taluk town or by the maintenance staff of the subdivision. In either case, a statement is prepared showing the pump identification, the date of repair, the spare parts replaced, the spare parts (if damaged) recovered and nature of repair (where necessary). The assistant executive engineer will transmit this data to the information cell.

In respect of (i) and (iii) above, the primary source of information to the assistant executive engineer is his own staff, and no difficulty in data collection is encountered. In respect of (ii), however, the users are to provide information. In order to encourage a prompt report of failure, a prepaid addressed "business-reply" kind of postcard can be handed to a responsible user after a new installation or each repair.

It is thus seen that the assistant executive engineer at the subidivision is the originator of all information needed for updating the data files. The information cell, as soon as the information is received, prepares the transaction file in the proper coding form and sends it to the computer centre. The centre codes the transaction file on punched cards, paper tape or other media, inputs it into the computer system, executes the updating program and replaces the old data file by the updated one.

4.3 *Output of information*

The main program, after processing the data file, outputs the following information:

(i) number of pumps in working order in each taluk included in the data file,

(ii) cumulative and relative frequencies of different modes of failure for a given pump,

(iii) frequencies of different modes of failure for all pumps in each given taluk taken together,

(iv) mean time elapsed between successive repairs and failures for each pump,

(v) mean time elapsed between successive failures and repairs for each pump (down time),

(vi) the status of each pump in the taluk *viz*, whether working or out of order.

(vii) mean life of each component of the handpump, and

(viii) reliability of the pump and its individual components.

The above output comes in the form of a listing indicating the names of the taluk and village, make of the pump, modes of failure, whether working or not etc. The output format is discussed in more detail in §6.

5. Organization of the system:

As already stated, the system consists of several data files, a program file, an updating file and a transaction file. The program file is envisaged to be unchanging unless additional output information is required other than what is provided in the present system. The updating file is also unchanging. The data files, on the other hand, are to be regularly updated, preferably every week, as detailed in § 4.2. The transaction file is temporary in nature, freshly prepared at the time of updating, and deleted after the new data file is created and verified.

5.1 *Data files*

The data file begins with a list of symbols and the number codes for the various parts of a handpump which figure in the failure modes. This list appears in the output each time the program is executed, for ready reference. A total of 36 components of the handpump have been identified as needing replacement periodically after scanning the records maintained by the PHE subdivision at Bangalore. Appendix B shows this list. There is a provision to add upto four more components if necessary.

The data proper follows this list and is organized as a sequential file in the manner shown in figure 1. Sequential access was preferred to direct access because of its simplicity and more efficient utilisation of core. The file is accessed sequentially anyway during program execution. The villages are arranged in alphabetical order and each village is given a three-digit code number in serial order. This code number is used by the updating program to access the correct record in the data file. Each taluk has a separate file in the system proposed here, but this can be easily changed by using the

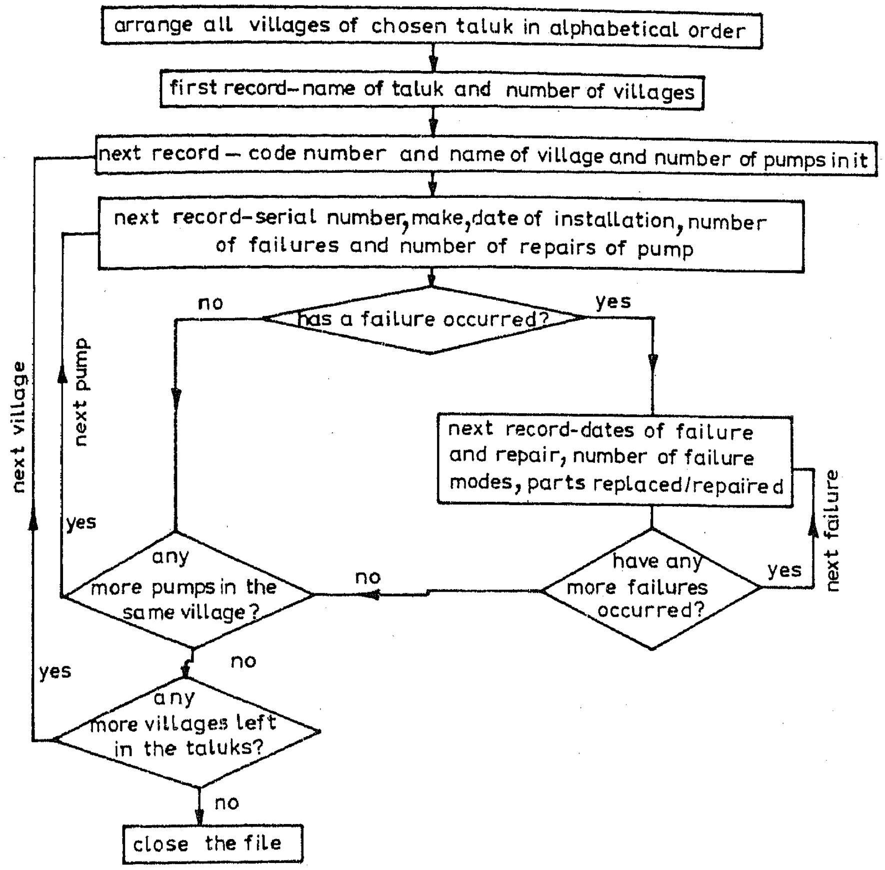

Figure 1. Organization of data file

editor of the computer system to merge several taluks into one file or to subdivide a given taluk into several files. The first record of the data file contains the name of the taluk (or region or any other unit, as the case may be) and the number of villages in the taluk. The latter tells the program how many times to execute a DO loop within which the calculations are performed. The next record contains the code number and the name of the village and the number of pumps installed in it. The purpose of the latter is to regulate another DO loop which reads the performance data of all the pumps in the village. Now follow the sets of records, one set for each pump in the village. Each set consists of one record containing the serial number, type, date of installation, number of failures and number of repairs of the pump in that order, followed by as many records as there are number of failures. Each of the latter records contains, respectively, the date of the concerned failure, the date of the subsequent repair, how many parts were replaced or repaired and the code numbers of the parts replaced or repaired during the repair of that particular failure. One record (*i.e.* one line) is thus earmarked for each failure-and-repair pair. Similar sets of records are provided for the rest of the pumps in the village. Then follows the record containing the code number and name of the next village and the number of pumps there. The data file for the taluk is built up in this way, the last record of the file containing information on the latest failure and the latest repair of the last pump in the last village of the taluk.

5.2 *Updating and transaction files*

The updating program produces a new data file by performing the following alterations in the old data file. When a new pump is installed, the first record of the concerned village is changed to increase the number of pumps there by unity. A new record is inserted (to follow the existing last record in the set for that village) giving the serial number, type and date of installation of the pump.

When a pump has failed, the first record in the set corresponding to that pump is changed to increment the number of failures by unity. A new record is inserted at the end of the set, where the date of failure is entered.

When a pump is repaired, again the first record of the corresponding set is changed to increment the number of repairs by unity. The last record of the set is also changed, inserting the date of repair, the total number as well as the individual code numbers of the parts replaced or repaired.

The transaction file contains the information needed for updating, and serves as the data for the updating program. It consists of as many records as are necessary for each village in respect of which the information is to be updated. The first record contains the code number and name of the village, followed by one record each for a new pump, repair or failure, containing the respective information as indicated above. Transactions for all villages concerned are prepared this way, and arranged in ascending order of the code numbers of the villages. The updating program reads sets of records alternately from the transaction file and the old data file and outputs a new data file containing the updated information.

5.3 *Program file*

Since the data is overwhelmingly numerical (more than 90% of the data file consists of numbers) and the task is largely computational, FORTRAN IV was the language chosen for the program. This language is as good as, if not better than, other languages for the job, and can be used, in particular, on the Karnataka Government computer. The program is a relatively simple one, and has a structure as shown in the flow chart in figure 2.

To start with, the desired data file would be assigned to the input unit before the program execution command is given, and after having read the preliminary list of symbols used in the printout and also different parts of the handpump (§4.2), the program reads the first record from this data file, which contains the name of the taluk and the number of pumps installed in all its villages. The summation variables for counting the number of pumps and number of failures in each mode are then initialized at zero. The next record in the data file which contains the name of the village and the number of pumps installed there is then read. The program then sets up a DO loop and reads all the data for all the pumps in the village which are contained in the records that follow as detailed in §5.1.

In order to calculate the number of pumps in working order, the program compares the number of failures and number of repairs of each pump. If the two are equal, the pump is in working order and the concerned summation variable is incremented by unity. At the same time, the word WORKING is printed against the relevant pump in the output. If the number of failures is greater than the number of repairs, the pump is not in working order. The summation variable is left unchanged and the words 'NOT WORKING' appear on the output. After the data for all the villages in the taluk are

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Note: The program, sample data, sample transaction and updating files are available with the authors.

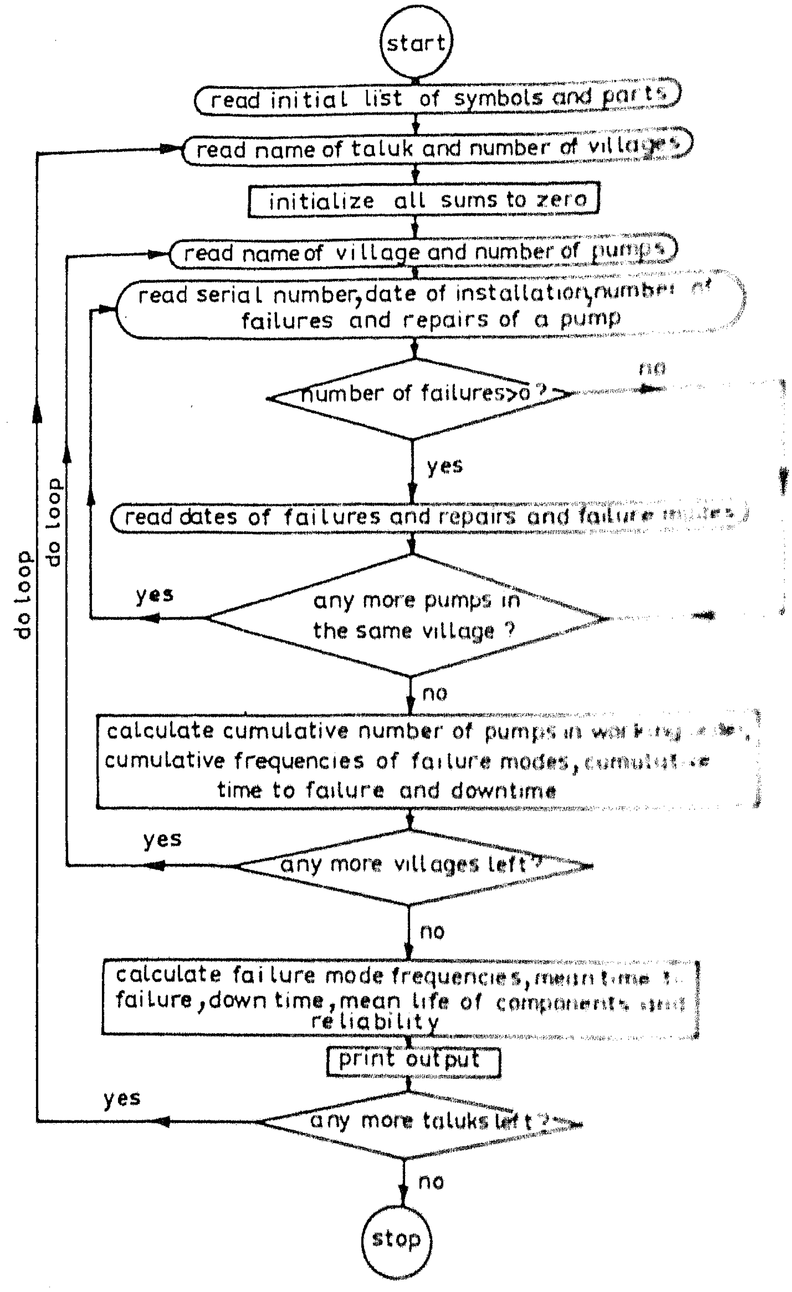

Figure 2. Flow chart of the program

processed, the final value of the summation variable gives the number of pumps working in the taluk.

By a similar procedure, the cumulative and relative frequencies of the different modes of failure for a given pump as well as for all the pumps in the taluk are calculated using a separate summation variable for each mode of failure.

The mean time between a repair (or installation) and a failure (MTTF) is calculated by averaging the intervals between the dates of repair (or installation) and the following dates of failure respectively. This is the average time for which the pump can be expected to work before a failure occurs. The mean time between a failure and a repair is also calculated similarly, averaging the interval between the respective dates of failure and the following repairs and gives the average downtime of the pump. The information can be used to decide the strength of the maintenance team in a given region or the State as a whole. The program can handle five type designations of pumps. They are here denoted by the letters A,B,C,D and E (each repeated five times). In implementation, they could be replaced by *e.g.*, the make of the pump.

5.3a *Reliability of the pumps*

The reliability of a pump is defined as the probability that the pump will still be in working order at the end of a specified time interval after its installation (Srinath 1975). The handpump consists of a number of components. Thirty six of these components figure in the modes of failure. Each of these components must be in working order if the pump is not to fail. The pump may therefore be considered as a system consisting of 36 components which are logically connected in series. The working of each component is independent of all other components and the failure of any one component will mean the failure of the system. Hence, the probabilities of successful working of the 36 components are all independent.

Let $p_i(t)$ be the probability that the ith component will be working at time t after installation. The reliability $R(t)$ of the pump as a whole is the probability that all the components will be working:

$$R(t) = p_1(t).p_2(t)\dots p_i(t)\dots p_{36}(t). \tag{1}$$

The probabilities $p_i(t)$ can be determined from the data records assuming a constant hazard rate, *i.e.*, that the ratio of the number of components which fail in a prescribed time interval to the total number of components in operation at the beginning of the interval (defined as the hazard rate or failure rate) is constant. The constant hazard rate model is valid for most situations. It can be shown (Srinath 1975) that if the hazard rate is λ_i, then

$$p_i(t) = \exp(-\lambda_i t). \tag{2}$$

The mean time to failure of the ith component, MTTF_i, is given by

$$\text{MTTF}_i = \int_0^\infty p_i(t)\,dt = \int_0^\infty \exp(-\lambda_i t)\,dt = \frac{1}{\lambda_i}. \tag{3}$$

From (1), (2) and (3),

$$R(t) = \exp\left[-\sum_i \frac{t}{\text{MTTF}_i}\right]. \tag{4}$$

If the value of MTTF_i is known, $R(t)$ can therefore be easily found. Comparing (4) with (2), it is easily seen that the overall hazard rate of the handpumps is

$$\sum_i (1/\text{MTTF}_i).$$

The value of MTTF_i for the ith component is obtained by the program by dividing the total number of pump-days of working by the total number of failures of the ith component. From the dates of installation, failures and repairs of each pump, the number of days for which the pump has worked upto the date of processing is calculated, and the summation of this number over all pumps in the data file is the total number of pump-days. The cumulative frequency of the ith mode of failure is the total number of failures of the ith component. The ratio of the former to the latter is the average number of days for which the ith component can be expected to work, *i.e.*, MTTF$_i$. This value is printed in the output as 'MEANLIFE' (Appendix B). The reliability of the pump, as (4) shows, decreases exponentially with time. A standard time point must therefore be specified when reliability is used to compare performance of different types of pump or before and after improvements etc. A period of one year (365 days, since MTTF$_i$ is in days) is a reasonable time for this purpose and the program calculates the reliability of the pump at the end of a year.

The value of $p_i(t)$, which is also the reliability of the ith component (at the end of a year), is output by the program, so that decisions can be taken on the components on which research or other effort at improvement must be concentrated. This value is calculated from MTTF$_i$ using (2) and (3). The overall hazard rate of the pump is also calculated from MTTF$_i$.

6. Test run of the program

For testing the program, a data file was prepared using the records maintained by the Bangalore PHE subdivision office. The Bangalore North Taluk was chosen and 35 villages in the taluk were arbitarily selected. Appendix A shows the beginning part of the data file. The data should not be taken as a representative sample.

The program was developed and executed on the DEC 10 computer system at the Indian Institute of Science. Appendix B shows a part of the output. This output should not be taken as representative of the actual state of affairs since selection of the villages was quite arbitrary. The latest date appearing in the entire data file was chosen as the date of processing (used in the reliability calculations).

The output format is as follows. The symbols used in the output and their meanings are listed first, followed by the components characterising the different modes of failure. The taluk is then identified, and the column headings follow in a row. The symbols used in this row have been listed in the beginning. The numbers 1 to 40 are printed in the next row, and correspond to the modes of failure in the second list from the beginning. The results for each village are thus printed in two rows. The first row contains respectively the number and name of the village, number of pumps installed there, serial number of the pump, date of its installation, last date of failure, total number of failures and repairs of the pump till the date of processing, mean time between repair and subsequent failure and that between failure and subsequent repair for that pump and lastly whether the pump is in working order or not at the time of processing. The second row contains 40 columns, each column indicating the number of times the corresponding component is replaced or repaired (*i.e.*, number of times the corresponding mode of failure has occurred). The results for the subsequent villages follow in similar fashion. After all villages are covered, the number of pumps in working order in the taluk is printed, followed by the number out of order. The penultimate page is then printed, consisting of a table with the following columns:

(i) mode of failure (identified by the code number of the component involved),
(ii) its cumulative frequency of occurrence (*i.e.* the number of times the component has failed upto the date of processing, taking all the pumps in the taluk together),
(iii) its relative frequency of occurrence (ratio of the cumulative frequency of the

particular component to the sum of the cumulative frequencies of all components), (iv) mean life of the component in days (which is the mean time to its failure), and (v) reliability of the component at the end of one year (probability that it will be in working order after a year).

Below the table are printed the overall hazard rate of the handpumps in the taluk and their overall reliability at the end of one year. In the final page of output, a typewise break-up of the pumps in the taluk is presented, indicating the total number of each type installed, how many of them are in working order and how many out of order.

Although the data used for the test run cannot be considered representative for the State as a whole, some results are worth noting. The number of pump days for the present data is 43694. Two of the components (bucket holder, code 7; lower C.I. nut, code 10) fail very rarely, and have not figured in the failures of handpumps in the present 35 villages. They have been assigned a mean life equal to the total pump-days and are included in the reliability calculations. Since their reliabilities are very high (0·992 each), even if they were left out the difference (1·6 %) to the overall pump reliability would be insignificant.

The calculated overall hazard rate of the handpumps is 9·28 % per week, and if the data were representative of the State of Karnataka as a whole, the maintenance organisation should have enough manpower, equipment and mobility to repair 4760 pumps per week. If the repair capability of the organisation is less, the number of pumps out of order would go on increasing, and the number of pumps in working order decreasing till the rate of breakdown equals the repair capability.

The overall pump reliability is 0·008. Interpreting this figure in probability terms, one can conclude that out of 1000 pumps, only 8 would be in working order after a year if no repairs are carried out in the meantime. To improve the overall reliability, the reliability of the individual components has to be increased. From Appendix B it is apparent that the five components which have the lowest reliabilities (of less than 0·7) are leather buckets (0·581), 1/2 inch checknut (0·591), lower set (0·637), upper set (0·658) and 1/2 inch coupling (0·681). The first fails by wear, swelling or distortion, the second and fifth signify disconnection of plunger rods and the other two relate to valve failures. Efforts to increase the reliability of these as well as other components of low reliability are therefore called for if the overall pump reliability is to improve. The hazard rate will so then come down, and the maintenance organization can be reduced in size.

he central processing unit of the DEC 10 system (capability: $1{\cdot}4 \times 10^6$ in- tions/s) takes about 1 s to process the data on 35 pumps. If a subdivision has 5000 s, the time taken to process the data file for that subdivision would therefore be 143 seconds.

clusions

the numbers involved, the management of drinking water for villages by means of umps requires a computerised information system. The system developed here data neeed for maintenance scheduling, inventory control and organization of towards improving the reliability of handpumps. The output can also be used to re the performance of different types of pumps.

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Appendix A. Beginning of the data file

```
Bangalore North                                                     35
 1 Adigana Halli                                                         1
1 DDDDD         28 777         3    3
  261080        311080       6    1   15   23   22   13   31
  201280        221280       5    2   26    1   24   19
   1 381         4 381       8    8    7   15   14   23   22   19   24
 2 Amrutha Halli                                                         1
1 EEEEE         30 579         7    7
  30 680         2 780       4    7   27   29   15
   4 980         6 980       4    7   15   22   23
  19 980        21 980       3    8   17   21
  151080        161080       6    7   15   22   23   28   29
  16 381        19 381       4    3    7   28   29
   2 681         5 681       4    8    7   14   13
  22 781        24 781       4   17    2    7   12
 3 Arakere                                                               1
1 CCCCC          9 477         8    8
  31 380        10 480       3   14   24   13
   3 780         7 780       3    8    7   19
  111080        161080       6    1    2   16   24   14   25
   1 381         5 381       6    1    2   14   24   19   21
  20 481        22 481       5    1    2   24   14   23
  16 681        20 681       1    1
  21 781        22 781       6    1    2   16   24   14   25
  10 881        20 881       3    8    7   19
```

Appendix B. Part of the output.

(a) Details of the symbols used in the program

I2 = Village Number
N = Number of pumps in the village
I3 = Pump number
NMT = Type of pump
NDI = Date of installation
NDNF = Last date of failure
NF = Number of failures
NR = Number of repairs
XMISUM = Average time elapsed between repair and failure in days
XNISUM = Average time elapsed between failure and repair in days

(b) Different parts of the handpump

1. Upper set
2. Lower set
3. Upper valve
4. Upper cage
5. Bucket fixer
6. Bucket holder
7. Leather bucket
8. Lower valve
9. Lower cage
10. Lower C.I. nut
11. Brass seating
12. Upper C.I. nut
13. Shackle pin
14. Ball bearing
15. Stroke rod
16. Handle
17. Brass body barrel
18. Brass body cylinder
19. ½" Bolt and nut
20. ¼" Bolt and nut
21. ⅜" Bolt and nut
22. ½" Checknut
23. ½" Coupling
24. Chain assembly
25. Guide bush
26. Lower washer
27. 1½" × 1¼" Reducing collar
28. 1½" G.I. Collar
29. 1¼" G.I. Nipple
30. Spring washer
31. Strainer
32. 1½" G.I. Pipe
33. ½" Plunger rod
34. Handle with bearings
35. Top head
36. Cylinder
37.
38.
39.
40.

(c) Name of the Taluk: Bangalore North

				I2		Name of the village									N	I3	NMT				NDI			NDNF			NF	NR			XMISUM			XNISUM			Working cond.		
																	Frequency of modes of failure																						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
					1	Adigana Halli									1	1	DDDDD				28	777		1	381		3	3			432·0			3·0			Working		
2	1	0	0	0	0	1	1	0	0	0	0	1	1	2	0	0	0	2	0	0	2	2	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
......																																							
......																																							
					35	Subedara Palya									1	1	CCCCC				13	477		18	880		3	3			399·0			3·0			Working		
1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2	0	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

No. of pumps working in the Taluk Bangalore North: 35
No. of pumps not working in the Taluk Bangalore North: 0

(d)

Mode of failure	Cumulative frequency	Relative frequency	Meanlife in days	Reliability at the end of one year
1	50	0·087	873	0·658
2	54	0·094	809	0·637
3	5	0·009	8738	0·959
4	1	0·002	43694	0·992
5	1	0·002	43694	0·992
6	0	0·000	43694*	0·992
7	65	0·113	672	0·581
8	20	0·035	2184	0·846
9	1	0·002	43694	0·992
10	0	0·000	43694*	0·992
11	1	0·002	43694	0·992
12	8	0·014	5461	0·935
13	23	0·040	1899	0·825
14	35	0·061	1248	0·746
15	38	0·066	1149	0·728
16	5	0·009	8738	0·959
17	6	0·010	7282	0·951
18	2	0·003	21847	0·983
19	41	0·071	1065	0·710
20	10	0·017	4369	0·920
21	16	0·028	2730	0·875
22	63	0·109	693	0·591
23	46	0·080	949	0·681
24	36	0·062	1213	0·740
25	5	0·009	8738	0·959
26	13	0·023	3361	0·897
27	4	0·007	10923	0·967
28	5	0·009	8738	0·959
29	5	0·009	8738	0·959
30	3	0·005	14564	0·975
31	6	0·010	7282	0·951
32	3	0·005	14564	0·975
33	2	0·003	21847	0·983
34	1	0·002	43694	0·992
35	2	0·003	21847	0·983
36	1	0·002	43694	0·992

Calculated overall hazard rate of handpumps = 9·280% per week
Reliability of the handpump = 0·008

*Implies minimum meanlife

(e) Typewise calculation of the working condition of the pumps in the Taluk Bangalore North

Total number of AAAAA pumps = 4
Number of AAAAA pumps working = 4
Number of AAAAA pumps not working = 0

Total number of BBBBB pumps = 1
Number of BBBBB pumps working = 1
Number of BBBBB pumps not working = 0

Total number of CCCCC pumps = 15
Number of CCCCC pumps working = 15
Number of CCCCC pumps not working = 0

Total number of DDDDD pumps = 8
Number of DDDDD pumps working = 8
Number of DDDDD pumps not working = 0

Total number of EEEEE pumps = 7
Number of EEEEE pumps working = 7
Number of EEEEE pumps not working = 0

** End of the calculation**