PLON Water for Tanzania

PHYSICS
IN
SOCIETY

Water for Tanzania

Pumping techniques in a developing country

PLON

Water for Tanzania

By the PLON project group for the 3rd form of secondary schools (14/15 years old)

Experimental edition

PLON / BV UITGEVERIJ nib ZEIST

PHYSICS CURRICULUM DEVELOPMENT PROJECT

* The Physics Curriculum Development Project (PLON) was started in 1972 under the auspices of the Physics Curriculum Innovation Committee (CMLN). Its terms of reference were to develop teaching packages on physics for junior and senior general secondary and pre-university schools, to evaluate such material by means of research, and to draw up a plan for directing its introduction into schools.
* The PLON is supervised by a steering group whose members have been drawn from schools, establishments of further education, educational support institutes, secondary teacher training institutions and the Ministry of Education and Science.
* The Project has been assigned to the Physics Education Department of the State University of Utrecht, which is also concerned with activities relating to the upper forms of senior general secondary schools. The development of instructional material for the upper forms of pre-university schools is carried out in cooperation with the Universities of Amsterdam (Municipal University) and Groningen and a group of teachers.
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Experimental edition.

contents

contents

introduction

PHYSICS IN SOCIETY

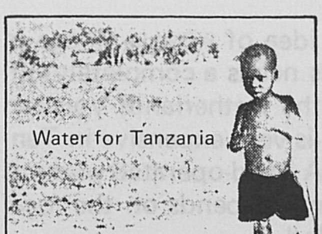
On the cover of this book you will see the words 'physics in society'. By that we mean world society, all the people in the whole world and how they live together. There is a great deal wrong with our society. Growing unemployment, pollution of the environment, armaments and — farther away — hunger and extreme poverty in Third World countries.
What has this got to do with physics? Well, a lot, really. By applying your knowledge of physics you can help to alleviate distress and solve problems, but physics can also create new problems. To give an example, physics made the development of the chip and micro-electronics possible. You profit by this because you can now perform quite complicated arithmetical operations on your pocket calculator. That's very nice for you, but the same development has led to people losing their jobs because computers have taken over their work. And that is the other side of the coin. So you see, physics and society are closely linked together.
That is the reason why you can do physics at school, or maybe have to, and why so much money is spent on physics. Not, of course, because of the problems physics creates (though what about nuclear weapons?) but because of the solutions physics can help to find. At the same time you should remember that what one person regards as a solution (for instance, building a nuclear reactor when there is a shortage of energy), another considers a big problem (radio-active pollution).
We are going to work out several examples of this in our themes on physics and society and help you to a better understanding of these controversial social questions. Some knowledge of physics will be needed. PLON has taken four themes that have to do with physics and society.

1. In *Water for Tanzania* you are going to study the improvement of the drinking water supply in developing countries

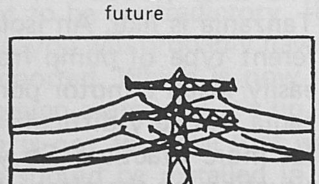
2. *Stop or keep moving* deals with the choice between a car, the train or a bike to get from one place to another.

3. *Energy in the future* is about the choice of energy supply. Sources of energy are expensive, they can pollute the environment, and are often an element in the (international) struggle for power. Which sources of energy should you choose?

4. *Nuclear weapons and/or security* deals with the nuclear arms race. Are nuclear weapons a threat to security or do they guarantee it?


Water for Tanzania

Stop or keep moving


Energy in the future


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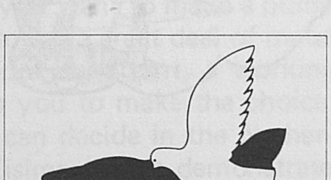


introduction

WATER FOR TANZANIA

INTERNATIONAL DRINKING WATER SUPPLY AND SANITATION DECADE 1981–1990

WATER AND SANITATION FOR ALL BY 1990

Insignia of the Water Decade

There is a great shortage of good drinking water in many countries in Africa, Asia and South America. People sometimes have to walk for miles to fetch water and even then it is often dirty and bad for their health. Dirty water can cause all kinds of diseases such as cholera, malaria and river blindness. The United Nations Organisation has proclaimed 1981-1990 the Water Decade (decade = period of 10 years). The idea is that during this decade all the people on earth will be provided with good drinking water and proper sanitation. Though we have the technical know-how to do this, there is not enough money available. Every house could be linked to a mains supply, but that is far too expensive. There are other, cheaper ways of providing water and this theme deals with one of them: pumping up clean groundwater with a single pump for a whole village.

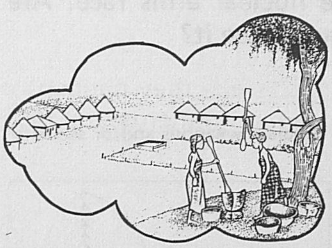
To illustrate how this can be done we have taken a simple, imaginary situation. In the little village of Kisima (which doesn't really exist) in Tanzania in Africa it would be possible to pump clean drinking water out of the ground. What would be the best type of pump for the purpose? To what requirements must the pump conform considering the village situation, and what do *you* think should be the requirements for a village pump?

WHAT ARE YOU GOING TO DO DURING THIS THEME?

Your role

You and your classmates are on the staff of the (imaginary) Technical Advisory Bureau for Africa (TABA) for the duration of the theme. This firm of consulting engineers has been asked by the Department of Development Cooperation to advise on a pump to be installed in the village of Kisima in Tanzania. Four working groups of TABA are each going to study a separate pump, build a model of it and express their opinion on its suitability. Each group will demonstrate its pump to the other TABA staff members (in other words your classmates) and say what they think about it. The whole 'office' will then decide which of the four pumps they will advise the Department to instal. You are going to play a role game – the meeting of TABA in which this decision is taken.

We are now going to discuss three difficult but important questions arising from the first part of the theme.



1. *What is a village in Tanzania like?*

The texts (Section 4) and films will give you some idea of what a village in Tanzania is like. An isolated farm in the Netherlands needs a completely different type of pump from a village in Tanzania. In the Netherlands you can easily instal a motor pump, but petrol for the pump is very expensive in Tanzania and very difficult to come by in the country. A hand-operated pump is far more practical. So you see, the choice of a pump depends on the *local situation*, on the place where the pump is to be installed.
That is why you must find out as much as you can about villages in Tan-

zania and what they are like. How many people live there? What is the climate? How do the people live? You can get some of these facts from the texts in Section 4, and from photos, films and slides. You may not be able to find the answers to all your questions, but then try to think them up for yourselves. Picture a Tanzanian village to yourselves. By talking about it among yourselves and using your imagination you could arrive at what *might be* the right answer. It's difficult, but try!

2. *What is your point of view?*

Opinion on Dutch aid to developing countries is very divided. Some people would say

– *Send the money to Kisima, then the people can buy the pump that they think best;*

Others may hold the view

– *We in Holland know all about pumps. It would be better to make a first-class pump here and send it to Kisima.*

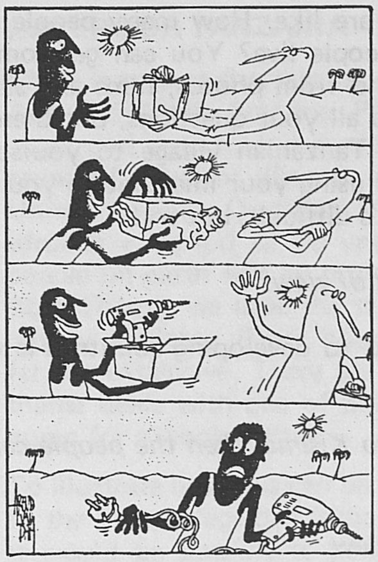
- Have you any arguments against these views?
- Try to give your own opinion.

Your choice of pump will be determined largely by the view you take. If you share the first view, you wouldn't choose a pump at all, but would probably opt for sending a pile of leaflets or do-it-yourself instructions to Kisima. If you agree with the second view, you'll make a special pump here and send that.
In this book four pumps are described which represent four different attitudes to development aid.

3. *What requirements must you lay down?*

You're now going to write down the requirements to which the pump for Kisima must conform. For instance, if there is suitable groundwater at a depth of 5 metres, the pump must be able to raise it from that depth at least. And there will be others to which it must conform because of the *situation* in Kisima. You'll be able to agree on the general lines of these requirements, but there are others that will obviously depend on *your point of view*. To give a couple of examples: as few foreign (non-Tanzanian) materials as possible should be used; the pump must keep working for at least 10 years without breaking down. Some of the others may not agree at all, since they happen to hold different views. Now the difficulty arises that two requirements you may consider essential turn out to be contradictory. If you want to make a pump that lasts at least 10 years, you will probably have to use a great deal of metal which will have to be imported. Which is now more important, a working life of 10 years or no foreign materials? It's up to you to make the choice. The object of this theme is not to prove that we can decide in the Netherlands what sort of pump should be installed in Kisima but to demonstrate what technical and social factors determine the choice of pump that could

introduction



be installed. And factors like that can play an important part in other situations as well (for instance in the Netherlands itself).

WHAT IS IN THIS BOOK?

Each section begins with a list of contents.

1. *Orientation*
Section 1 contains the Department of Development Cooperation's letter commissioning TABA to advise on a suitable pump for Kisima. It also contains a number of activities that will help to give you some idea of what the village is like.

2. *The working groups*
Section 2 gives information on the four pumps you are going to examine.

3. *How the pumps work*
Section 3 is a physics lesson on the construction of the pumps and how they work.

4. *Texts for reference and further reading*
The texts in Section 4 deal with drinking water problems in developing countries and with Tanzania generally. You are to use them when carrying out the activities in Section 1. You can find the text you need for a certain subject by consulting the list of subjects at the end of the book.

1 orientation

contents

1-1 TABA'S ASSIGNMENT

The imaginary firm of consulting engineers, TABA, on whose staff you are for the duration of this theme, received the following (fictitious) letter from the Department of Development Cooperation.

Department of Development Cooperation
The Hague.

Technical Advisory Bureau on Africa
16 Waterstraat,
IJsseldam.

Dear Sirs,

As part of development cooperation between Tanzania and the Netherlands, this Department has earmarked certain funds for the improvement of the drinking water supply in the village of Kisima, situated in the Shinyanga region, Tanzania.

A site has been located near the village where groundwater of excellent quality suitable for drinking is present at an easily accessible depth (5 metres). A pump is to be installed so that water will be available to the whole village. We have decided, together with the Tanzanian water supply department, Maji, that the pump should meet the following requirements. (The sequence in which they are given is arbitrary; we have not gone into the question of which is the most important).

1. The operation of the pump must not require an expensive source of energy (petrol, electricity).
2. The pump must be made of materials obtainable locally as far as possible.
3. The pump must require as little maintenance as possible; it should be possible for the villagers to carry out any repairs themselves.
4. The pump must be as cheap as possible.
5. The construction must be such that it will be impossible to pollute the water in or near the well.
6. The capacity of the pump must be sufficient to supply the needs of the village.

I invite you to advise the Department on the most suitable type of pump for Kisima. The pump must conform to at least four of the above six requirements.

You may be interested to know that this is a pilot project. Should the Kisima pump prove satisfactory and its maintenance raise no particular problems, we plan to instal similar pumps in other villages.

Yours faithfully,

J. de Wit
Tanzania division.

1-2 SHORT REPORT ON THE DISCUSSION AT THE DEPARTMENT
by two TABA staff members

After receiving the Department of Development Cooperation's letter about the choice of a pump for Kisima, Tanzania, we had talks on behalf of TABA with a number of officials at the Department. We wanted to find out more about the situation in the village because the choice of pump depends very largely on local conditions. Unfortunately we did not get much information on the subject, though we were given some photos with a certain amount of explanatory material which you will find at the end of this report. Various books and articles were recommended and we have given information from them in Section 4. What we did discuss in detail were the six requirements.

1. *Not dependent on expensive sources of energy*

There is no electricity in Kisima. Only the bigger towns in Tanzania have an electricity supply. Fuel such as petrol and diesel oil is difficult to obtain. Since the 1973 energy crisis and the subsequent sharp rise in the prices of oil products, the energy situation in Tanzania has become considerably more problematical.
The Department thought a hand pump would be the best. We also discussed windmills and a pump operated by draught animals. But Shinyanga is by no means a windy region and windmills are apt to break down easily. As for draught animals, a pump operated by an ox or a donkey was out of the question as there are not even enough animals to work the land.

2. *Locally obtainable materials*

Materials like wood, clay, stones, straw and leather are to be had locally. Such industrial products as oil drums, car tires, buckets, gas pipes, plastic tubing, etc., are fairly easy to obtain. They can be bought in the nearest town, but transport is a problem in the rainy season as the (dirt) roads become impassable. The bus that serves Kisima once a week (the 'highroad' is about 5 km from the village) cannot get through once the rains start. Cement, oil, nuts and bolts, all metals and similar materials are extremely scarce, either because they have to be imported or because there is a big demand for them.

3. *Maintenance*

Maji, Tanzania's drinking water supply department, employs a number of mechanics who keep an eye on the pumps in the villages. But in practice they rarely manage to visit every village more then once every six months. In sparsely populated areas, like the one in which Kisima is situated, visits will be even more infrequent because of the great distances and the bad roads.

4 and 5. *As cheap as possible and no pollution*

We needn't go into these two requirements except to point out that the cheapest pump is not always the best and the cleanest pump is not always the cheapest.

6. *Enough water*

It has been found that villagers fetch water from the old wells and springs if they have to wait too long at the pump. There is a sort of 'rush-hour' at about 7 o'clock in the morning when nearly everyone comes to fetch water for cooking and another 'peak' at 6 in the evening; in between less use is made of the pump.

We cautiously inquired what the Department's views were on the choice of the pump and whether they had any particular preference, but, apart from the six requirements stated in the letter, they had no special demands. They said, 'We've already stated that the order in which the requirements were given was arbitrary', so in other words, you are free to have your own opinion on the subject.

ACTIVITY 1 Tell one another in your own words what TABA's assignment from the Department was.

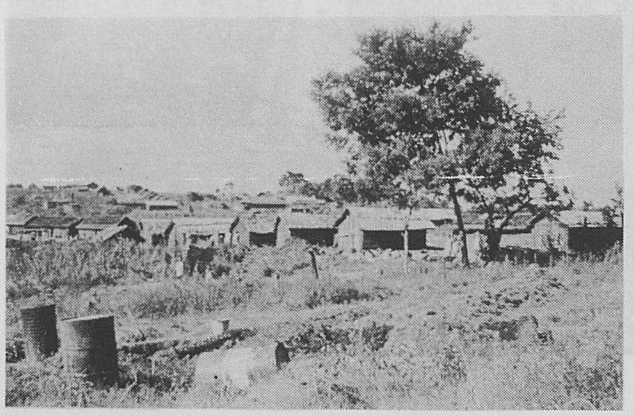
ACTIVITY 2 Are there words or sentences in the Department's letter which you don't understand? Look them up in the list of subjects at the end of the book which will refer you to the reference texts where you can look for an explanation.

ACTIVITY 3 Think up a reason for each of the requirements laid down by the Department.

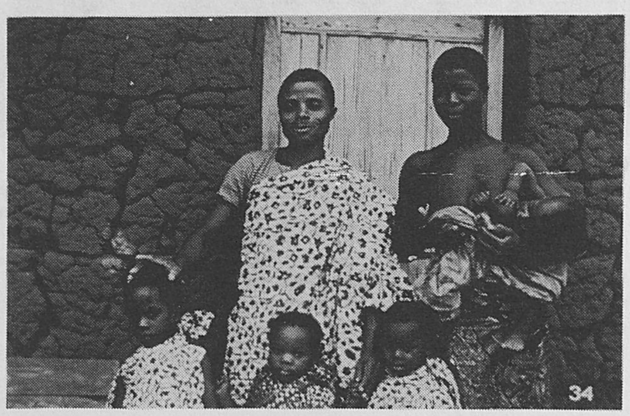
ACTIVITY 4 Are there conflicting requirements? If so, which? Why?

ACTIVITY 5 Write down what you consider to be the two most important requirements and the two least important. Give an explanation.

Study the photos carefully. What do they tell you about life in Kisima?

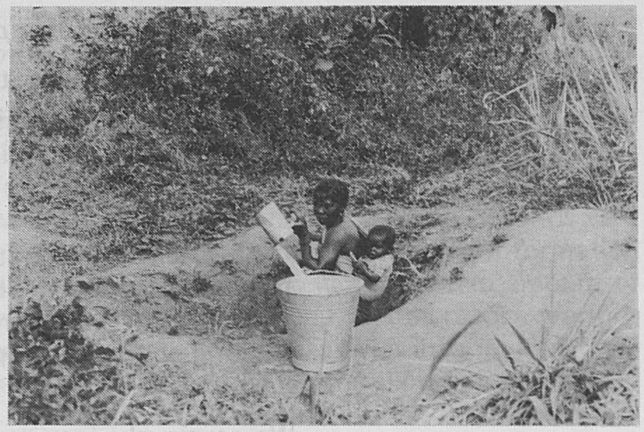


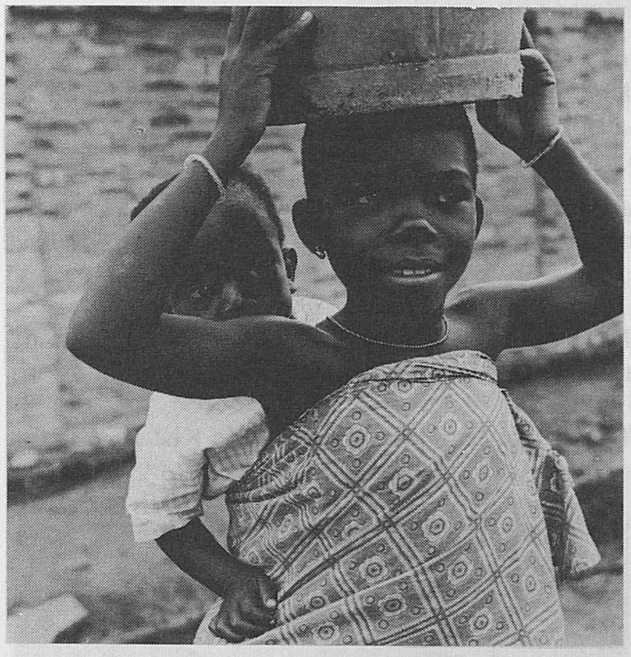
The village is situated in fairly flat savannah country in the Shinyanga region in north west Tanzania.



One of the 50 families in the village.
Income: *f* 200,– a year.

In the rainy season the pools are full of water. The women do their washing in these pools and draw drinking water from them. A snail living in the water can cause *Bilharzia*, a disease which can be contracted merely by standing in the water with bare feet.





Children must help too.

In the dry season the women have to go a long way to fetch water. They carry buckets of water and vegetables to the village on their heads. It's heavy going. Try doing it yourself. ▶

orientation

Towards the end of the dry season water gets very scarce. There is still some to be found in a deep pool in a river bed 5 km from the village.

1-3 THE INSTALLATION OF PUMPS IN AFRICA

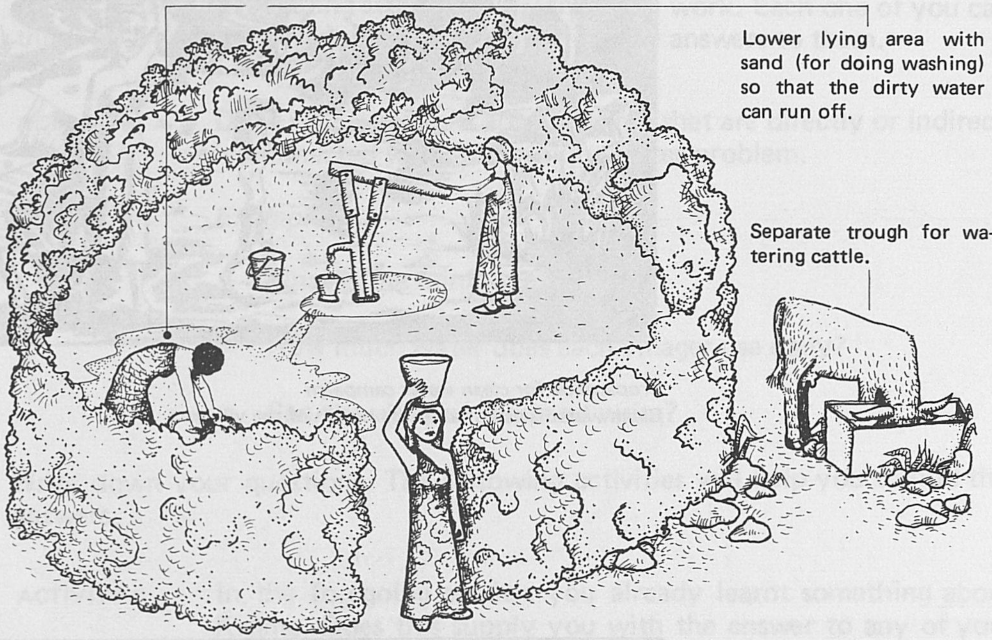
TABA has already some experience of installing pumps in villages in Africa and has learnt a great deal in the process. Fifty percent or more of the pumps break down within a year or are simply not used. It is evident in the photo below that this pump is no longer working. You can read more about it in text 4.

ACTIVITY 6 Study the photo carefully.

a. How can you tell that the pump has broken down?
b. What is wrong from the point of view of hygiene with drawing water from the well the way these women are doing?

When the pumps are inspected, it often turns out to be quite easy to repair them. Some part has worked loose or has broken off. But the problem is that nobody in the village has learnt to check the pump regularly, to grease it and to tighten any loose screws. Nor are there any spare parts in the village. If spare parts are ordered from town, it can take months before they are delivered and even when it's very likely that they won't fit; the bolt is one size too big or the thread of the screw is just slightly different.

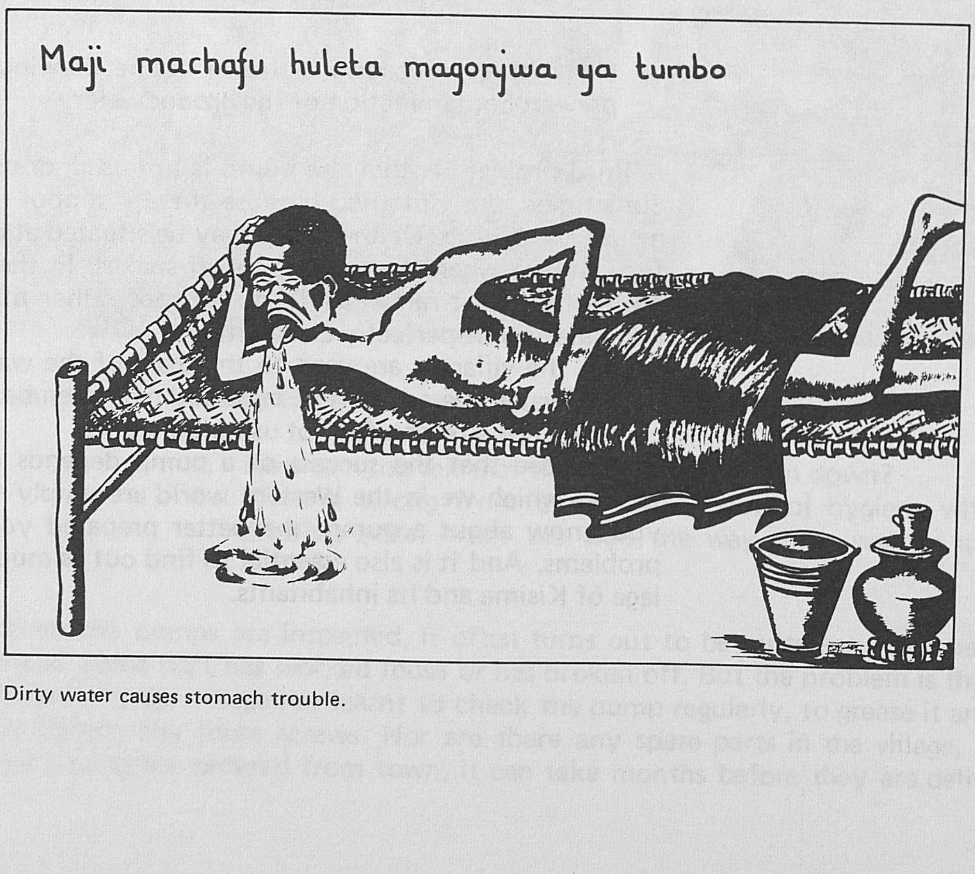
A second problem is that the water in the well gets contaminated. All sorts of activities take place in the neighbourhood of the well: washing is done there, cattle come to drink, children play there. Dirty water and urine sink into the ground and pollute the groundwater. Special precautions must therefore be taken.



— Name three precautions shown in the drawing that have been taken to prevent contamination of the groundwater.

A third problem is that the pump is not used, or used only in the dry season. Sometimes it is not used because there is a pool (with contaminated water) nearer the village. Or the pump may be situated at an 'evil' or dangerous spot, for instance where there are a lot of snakes. In the rainy season the villagers prefer to collect rainwater from the roof rather than walk to the pump, but rainwater is not perfectly clean either.
Lastly, the villagers are used to the taste of the water from pools and rivers. Groundwater has a different taste and may even be of a different colour. This could also be a reason for not using the pump.
So you see that the success of a pump depends on a great many different factors which we in the Western world are simply not aware of. But the more you know about a pump, the better prepared you'll be to tackle all these problems. And it is also essential to find out as much as possible about the village of Kisima and its inhabitants.

Propaganda for clean water campaign
Clean water is essential to the health of the villagers.



Dirty water causes stomach trouble.

1-4 A PICTURE OF LIFE IN KISIMA

The more you know about the village, the better prepared you'll be to tackle the problems and the sounder your recommendations about the pump will be. So you must go in search of information about Kisima or about villages in general in Tanzania. There are various sources of information you can consult. First of all there are the texts for reference and reading in this book, but perhaps there are also slides, films, books from the library and other teachers at school or people you may know who have worked in Africa. You needn't all try to find out everything straight away; share the work. Each one of you can think up a number of questions and try to find the answers to them.

ACTIVITY 7 Draw up 5 questions about Kisima that are directly or indirectly connected with the drinking water problem.

Examples:

- What is the rainfall in Kisima?
- How much water does each villager use daily?
- Can the villagers read and write?

Write down your questions. The following activities will help you to find the answers.

ACTIVITY 8 In the foregoing section you already learnt something about Kisima. Does this supply you with the answer to any of your questions?

ACTIVITY 9 Watch a film about Tanzania or some other African country. Does the film supply an answer to any of your questions? What else has it taught you?

ACTIVITY 10 Consult one of the texts for reference and reading at the back of the book that has to do with one of your questions. The list of subjects on page 71 will help you find the text you need.

ACTIVITY 11 Go to the library. What books have they got on Tanzania? Try to find the answer to one or more of your questions in one of these books.

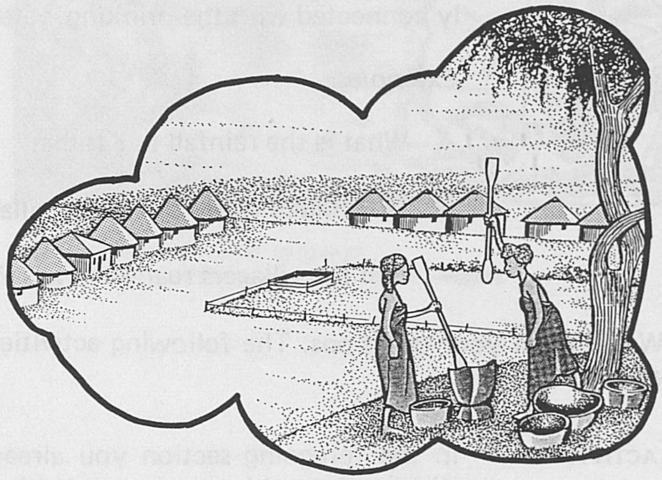
ACTIVITY 12 Perhaps somebody who has worked in a village in Tanzania or another African country is living in your neighbourhood. Ask this person about life in an African village. Can he or she answer any of your questions?

orientation

These activities will give you some idea of what the village of Kisima may be like. What is your idea of the village? Have you all got more or less the same idea? Activity 13 will help you to find out.

ACTIVITY 13 You are going to explain to one another what you think Kisima is like. You may each choose your own way of doing so. You have the following options:

- an essay or story
- a drawing
- a model of a village
- a play
- a . . . . .



There are perhaps still some important questions to which you have not been able to find the answers. Discuss them in class and you may together find the right answers or be able to make up plausible ones.

2 the working groups

contents

the working groups

INSTRUCTIONS FOR THE WORKING GROUPS

TABA got ideas for four pumps from four different quarters.

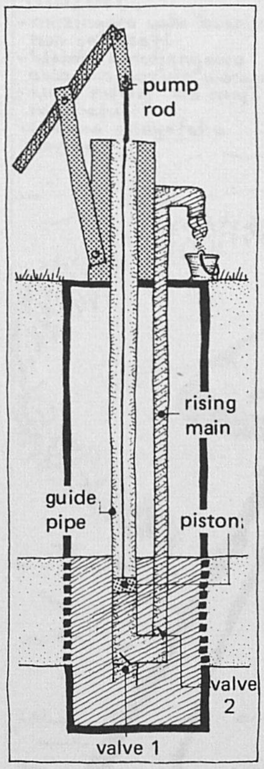
They are:

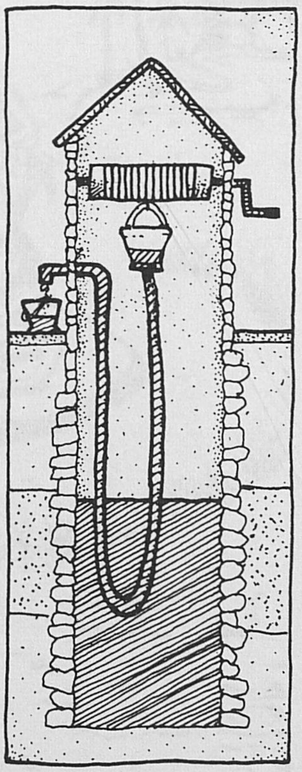
1. A displacement pump made in the Netherlands. A leaflet issued by the manufacturer is reproduced below.

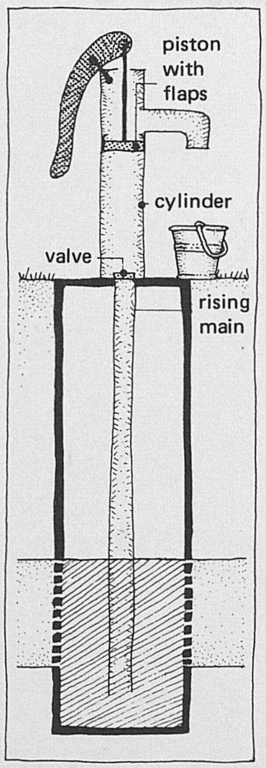
2. A 'hose-and-bucket' pump described in a letter from a Dutch volunteer working in Kenya.

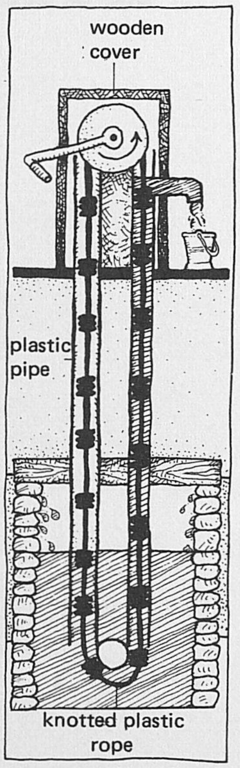
3. A suction pump made in Tanzania. You'll find a short report of a talk between a representative of the Tanzanian manufacturer and one of the staff of TABA who happened to be in Tanzania and discovered this small firm in the capital quite by chance.

4. A rope pump described in a South American magazine.









Perhaps one or more of the groups will have their own ideas about a pump for Kisima which they may be able to work out in consultation with the physics teacher.

the working groups

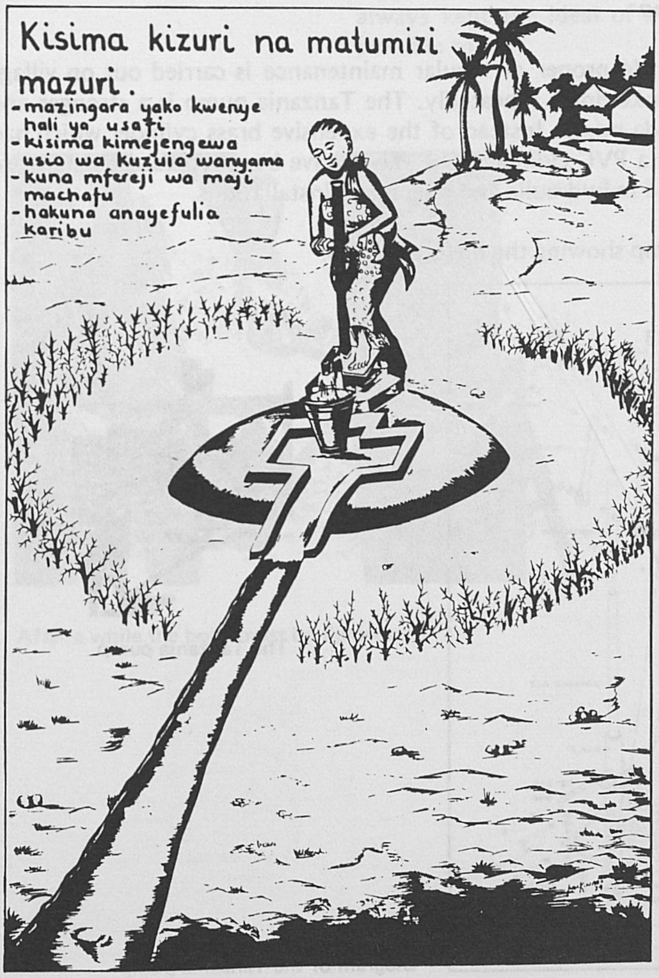
Each group will examine one pump. In other words, each group:

1. will study how the pump works. How the 4 pumps work is explained in Section 3;
2. will determine which of the Department's six requirements are met by the pump;
3. will examine on what grounds the pump is recommended and what additional requirements this may entail;
4. will study a model of the pump or will make one introducing improvements if possible;
5. will estimate the cost of the pump;
6. will advise on the pump, giving arguments for and against.

At the end of each of the four short studies of the pumps you will find instructions on how to make the models. The real pumps will be bigger and the materials used will be different but the principle remains the same. We have chosen materials that are easily obtainable in the Netherlands and easy to work with. Quite different materials may be used in Tanzania. When the groups have completed their study of the pumps they will each report their findings at a TABA meeting. The meeting will then discuss which pump is most suitable for Kisima and a decision will be taken.

The fine well is being wrongly used:

a. The surroundings of the well are dirty.
b. Cattle can come and drink at the well.
c. The women wash clothes near the well.
d. Nothing is done to keep out the cattle.



A fine well is being properly used:

a. The surroundings of the well are clean.
b. Measures have been taken to keep out cattle.
c. There is a runnel to carry off dirty water.
d. Nobody relieves himself near the well.

WORKING GROUP 1 The displacement pump

A leaflet produced by the firm of consulting engineers Verhage BV in Rijndam is reproduced below. The firm, which has carried out a big pump installation project in Tanzania, developed a special Tanzania pump on the displacement pump principle. You'll find more information on the displacement pump on page 45.

THE TANZANIA PUMP: ROBUST AND INDESTRUCTIBLE

Our firm has developed a hand pump for use in the rural areas of Tanzania. It is based on the Uganda pump used by UNICEF, but has been considerably improved after try-outs in Tanzania itself.

Requirements for a hand pump

A hand pump which can be used for fairly shallow wells (to a depth of 30 metres) in developing countries must meet certain requirements.
Two of the most important are:
1. The pump must be as simple as possible and require practically no maintenance.
2. The cost per pump must be as low as possible.

The parts of the Tanzania pump

Experience has shown that little proper or regular maintenance is carried out on village pumps. The Uganda pump broke down repeatedly. The Tanzania pump is a stronger and improved version of the Uganda pump. Instead of the expensive brass cylinder which had to be imported, we have used a PVC cylinder. The valves have been replaced by standard parts which are commonly used in hydraulic and pneumatic installations.

A diagram of the Tanzania pump showing the different parts.

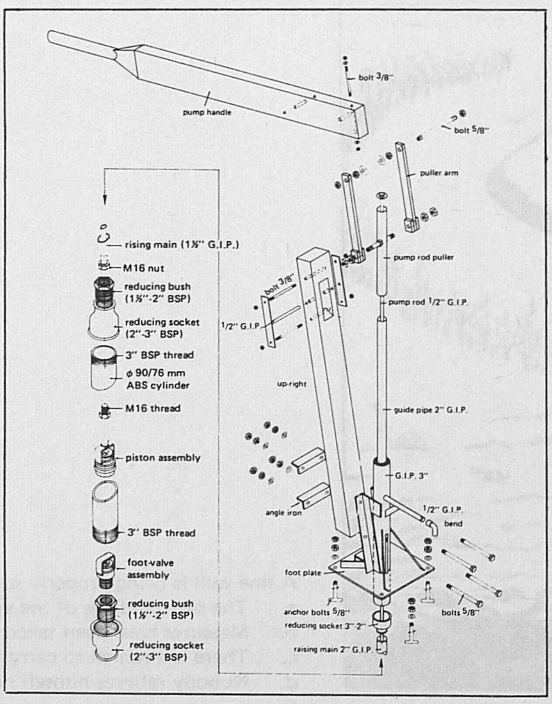
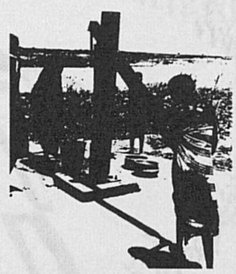


Diagram of the Tanzania pump



The Tanzania pump

the displacement pump

Pumping capacity

Pump cylinders of 3 different diameters are used: 4, 3 and 2 inches.
The pumps have the following capacity at one stroke per second and a 75% effective pumping time:

4 inch cylinder	2,000 litres per hour
3 inch cylinder	1,200 litres per hour
2 inch cylinder	600 litres per hour.

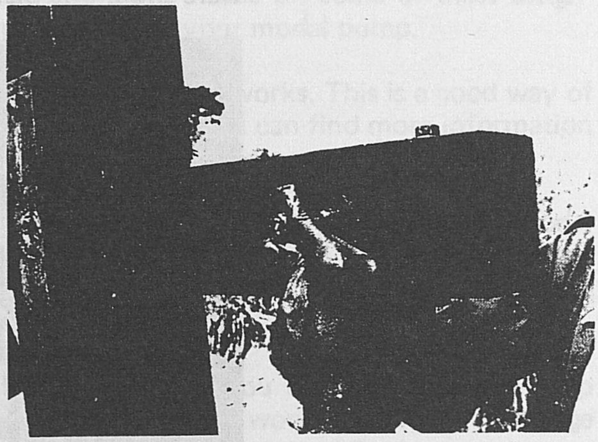
The 4 inch cylinder can be used to a depth of about 10 metres, the 3 inch to 20 metres and the 2 inch to 30 metres.

Cost of installation and maintenance

One pump costs *f* 1,500, including parts, transport and installation. The price is based on the assumption that 99 other pumps will be installed at the same time in the same region.

Ideally, once a pump is installed, it should always give good quality water without having to be repaired or overhauled. Such a pump does not exist, of course. Every pump needs regular maintenance. Nevertheless, in designing and constructing this pump, our firm has always kept the ideal of a maintenance-free pump in mind. That is why it is as cheap as possible to use.

After a while the bolts must be tightened.



The movable parts must be kept well greased.

the displacement pump

Maintenance costs can be reduced further by involving the local population in the pump's maintenance and surveillance. Only two thorough revisions by government mechanics will be needed annually, costing only *f* 100,– a time.

A good pump with good water.

A model of a displacement pump

You can make a model displacement pump from PVC tubes bought at a hardware shop. The piston can be made from two pieces of cork with a rubber disc

A model displacement pump made from PVC tubes. In Tanzania the pump is meant to keep your feet *out of* the water, to avoid Bilharzia-infection.

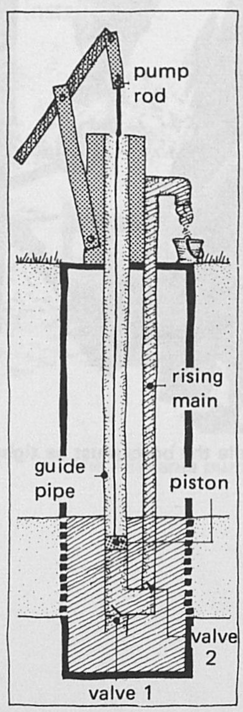
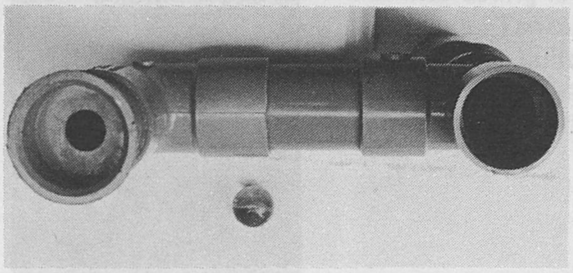


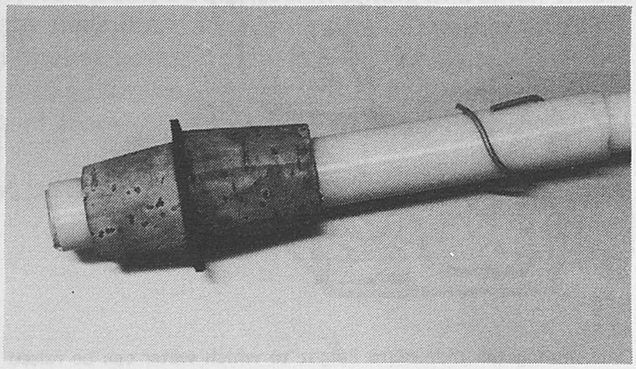
Diagram of the displacement pump

the displacement pump

wedged in between. The disc must fit exactly into the tube. A narrower PVC pipe can be used as the pump rod. The best way to make the valves is to bore a hole in the endpiece of the tube which can be closed with a marble.



The marble valve of the model pump



One way of making the piston. Note how the piston differs from that of the suction pump on page 36; the corks are reversed.

Assignments

1. Carry out the assignments given in 'Instructions for working groups' on page 23. Below you will find additional notes on some of these assignments, which have to be carried out using your model pump.

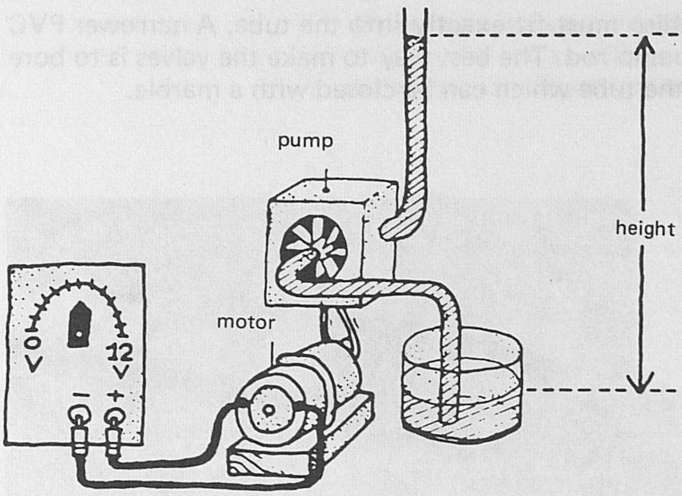
2. Explain to one another how the model pump works. This is a good way of preparing your demonstration to the class. You can find more information about the working of the displacement pump on page 45.

3. How long does it take to pump up 10 litres of water with your model pump? (Pump steadily and don't hurry!) And with a real displacement pump? For how long will the pump be used every day if every inhabitant of the village uses 10 litres of water a day?

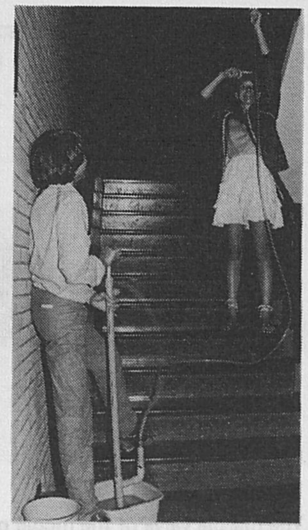
4. Your model pump is about 1 metre high. You can therefore pump up water from a depth of about 1 metre. How would you have to change your model in order to raise water from a greater depth?

5. Determine the maximum height to which water can be raised by your pump. In 'Working with Water' you were able to do that as shown in the sketch on the next page.

the displacement pump



Determining the maximum height to which water can be raised in 'Working with Water'.



In the photo you can see how to do this with the displacement pump. Think up how you could change your model in order to increase the height. Try it out to see if it works.

6. Do you think it takes longer to pump up water from a depth of 1 metre than from depths of 2 and 5 metres? Try it out.

WORKING GROUP 2 The hose-and-bucket pump

A product of tradition and development

An interesting letter from Elly van Dam, a volunteer working in a small village in Kenya, Tanzania's northern neighbour, is given below. Together with the villagers she built a hose-and-bucket pump which was a great success. Her letter explains what the pump looks like, how they built it and what problems they encountered. You can read more about this type of pump on page 45.

Kenya, 23 April

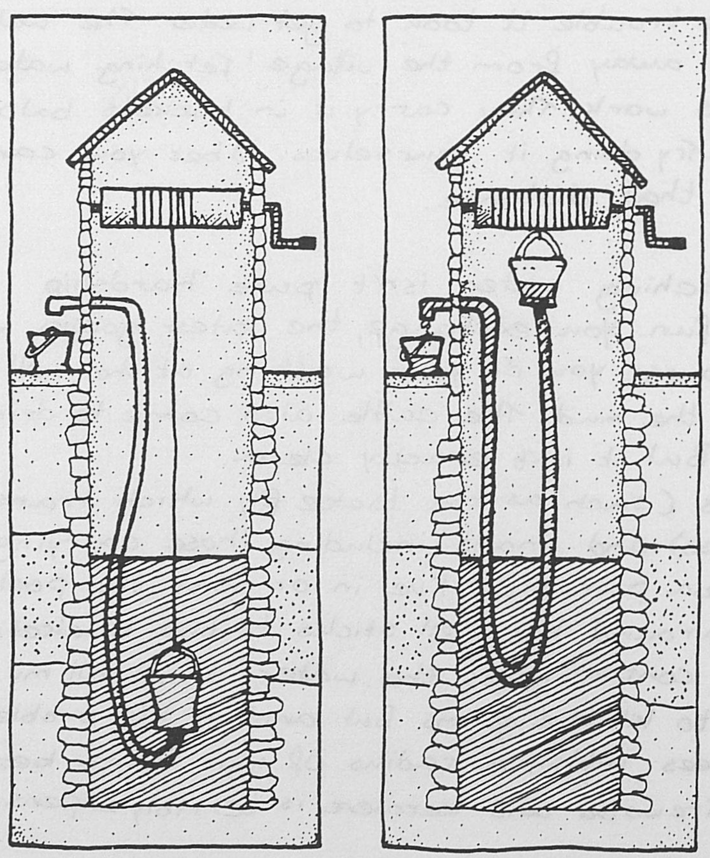
Hallo there!

The rainy season has started and all the people from the village have gone to the fields to sow and plant so I've taken time off to tell you about a pump we built here. You may be able to make use of the idea in your work in Africa.
When I arrived here eighteen months ago to work on "village development", the first thing that struck me was the trouble it took to get water. The well was 2 kilometres away from the village! Fetching water in Africa is women's work. They carry it in buckets balanced on their heads. Try doing it yourselves. I bet you can't keep it up for that distance.

But fetching water isn't pure hardship. It can be quite fun. You exchange the latest gossip with your neighbours, you do your washing at the well and the kids play in the mud. The cattle also come to drink at the pools. But it isn't exactly clean.
Insects (such as the tsetse fly which transmits sleeping sickness) and snails (including those carrying the Bilharzia parasite) live in or near the pools. And the mud around the well sticks to the buckets lowered into it and contaminates the water. I boil all my drinking water to kill the germs. But another big problem here is fuel. The trees within a radius of 4km have been cut down for firewood and kerosene is terribly expensive.

the hose-and-bucket pump

So the villagers only boil water if its really necessary, for instance to make porridge for supper.
It was clear that the village water supply had to be improved. I happened to hear from another volunteer that aerial photos had been taken of the area and that they had revealed water-bearing strata in the soil in the neighbourhood of the village. To cut a long story short, we found a stratum 500 metres from the village, dug a new well there and struck good, clean water at a depth of 2½ metres. But how do you keep it clean while raising it to the surface? A pump costs a lot of money and I've seen a lot of pumps, one way and another, in Africa. Beautiful designs. But... no go. All out of action. And no spare parts to fix them. Sooner or later a pump is bound to break down, it's one of the facts of life, but if the village women who use the pump can repair it themselves, it doesn't matter so much. That's why I made a very simple pump, the hose-and-bucket pump.



the hose-and-bucket pump

It's easy to understand how the pump works. The water in the hose must be at the same level as the water in the bucket. But if you raise the bucket above the discharge outlet, the water will run out. The pump has a lot in common with the traditional "bucket on a rope". The biggest problem when making the pump was to find a length of suitable hose and to fix it to the bucket. Well, I found it in town. And I also found a smith who soldered a short length of metal pipe into the bottom of the bucket.

The village is enthusiastic about the well they dug themselves and the pump they made themselves. We had one small difficulty at the beginning but it was soon overcome. The pump was not quite finished but was already being used. A woman filled her bucket but left the end of the hose hanging in it. When she started lowering the hose-bucket, the water in her own bucket was siphoned back into the well. She got a terrific fright.

I realised that if there was going to be something mysterious about the pump, the villagers probably wouldn't want to use it.

I let her feel that the hose "sucks" when you lower the bucket; you feel it quite distinctly if you put your finger just inside the hose. This convinced her that there wasn't some evil spirit at work, which was a good thing. After that we fixed the hose at the outlet so that it couldn't happen again.

Well, that's about it. I hope that my pump, which has been going strong for more than a year now, will continue to do good work (with regular repairs) after I've left, which I'm due to shortly. I hope my story will be of use to you.

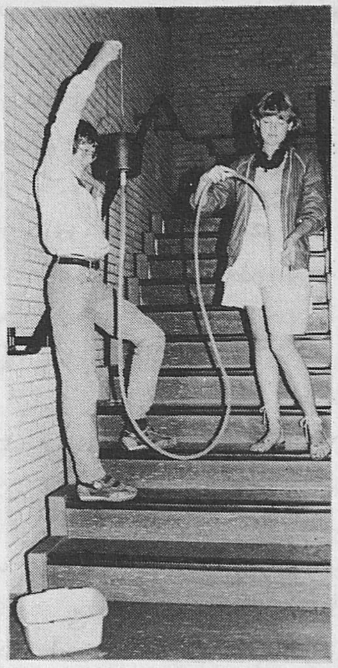
Best wishes

Elly.

A model of the hose-and-bucket pump

You can easily make a model of the hose-and-bucket pump yourselves. Elly has given a few tips in her letter. The material you use depends on what you can find because almost anything is suitable. The photo of a model should be a help though it has no device for raising the bucket.

the hose-and-bucket pump



Model of the hose-and-bucket pump without device for raising the bucket

Assignments

1. Carry out the assignments given in 'Instructions for working groups' on page 24.
   Below you will find additional notes on some of the assignments, which have to be carried out using your model pump.

2. Explain to one another how the model pump works. This is a good way of preparing your demonstration to the class.
   Explain siphonage to each other. You'll find more information about it on page 47.

3. How long does it take to pump up 10 litres with your model? And how long do you think it will take using a real hose-and-bucket pump if that happens to be the one chosen for Kisima? For how much of the day will the pump then be in use?

4. How could you modify the pump so that it takes less time to raise the water?

5. What is the maximum depth from which you can raise water with a hose-and-bucket pump? How could you improve this?

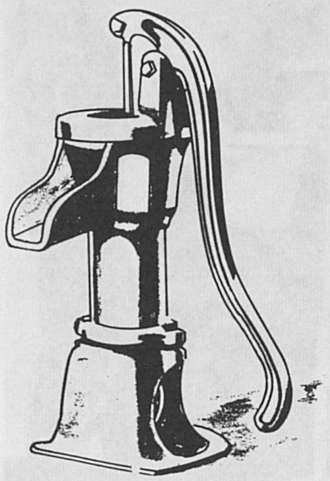
the suction pump

WORKING GROUP 3 The suction pump

One of the staff of TABA who is stationed in Dar-es-Salaam, the capital of Tanzania, came across a small pump factory there. He wrote the following article for the TABA house magazine.

The Maji Pump, made in Tanzania

You often come across the Maji pump in the villages around Dar-es-Salaam. Maji is the Swahili word for water. The Maji pump is a suction pump and the villagers are very satisfied with it. I made inquiries about it in a number of villages.



The Maji pump

A mechanic from the Maji pump factory visits regularly to inspect the pump. The washers are renewed, the valves checked, the bolts tightened, the movable parts greased and the parts that have rusted are red-leaded. If anything breaks down between the regular revisions, the factory is informed and a mechanic arrives within a few days to do the necessary repairs. When the new washers in the piston have been in use for a month, they start leaking through wear and tear. This can be easily fixed by throwing water on the piston, thus creating a water seal, and this is often done in the villages. From the point of view of hygiene this is not to be recommended. The water thrown on the piston is often contaminated and seriously affects the quality of the pump water.
I discussed this problem and the success of the Maji pump with the managing director of the factory. He ascribed its success to the service the factory gives. 'I'm envious of the high quality of the foreign pumps installed here', he said. He uses mainly cast iron of a rather inferior quality but better quality cast iron is unobtainable in Tanzania. 'Yet our pumps are more popular than the foreign ones in the long run. Ours may well break down sooner, but at least we have the spare parts in stock. Spare parts for foreign pumps are simply not to be had.'
He is not unduly worried about the pollution of the water through the water seal. 'When I think of the water I used to drink! Incredible! But I survived. We Tanzanians are tough. The main problems of the drinking water supply are not pollution or contamination; they are the distance people have to walk to fetch water, and the mud, the pools of water round the wells which are breeding grounds for mosquitoes, the Bilharzia snail and so on. And these problems are solved by installing a Maji pump.'
He did concede that it was better to have completely clean water. 'But we have to choose between making a displacement pump and a suction pump. In a displacement pump the pistons and valves are under water, so it's difficult to get at them if they need repairing. In a suction pump they are in the top part and easily accessible. So we plumped for a less than ideal suction pump that is easy to repair rather than for a clean displacement pump that is difficult to repair.'
The argument that you can't raise water with a suction pump from a depth of more than 6 metres doesn't bother him, as most of the wells aren't deeper than 5 metres anyway. Though the Maji factory currently supplies only villages in the neighbourhood of the capital, the managing director has plans for supplying and servicing other parts of Tanzania as well.

A model of a suction pump

You can make a model of a suction pump. The photo shows one made of PVC tubes which you can buy at a hardware shop.

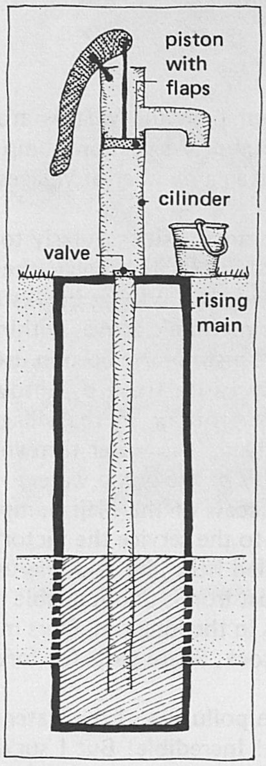
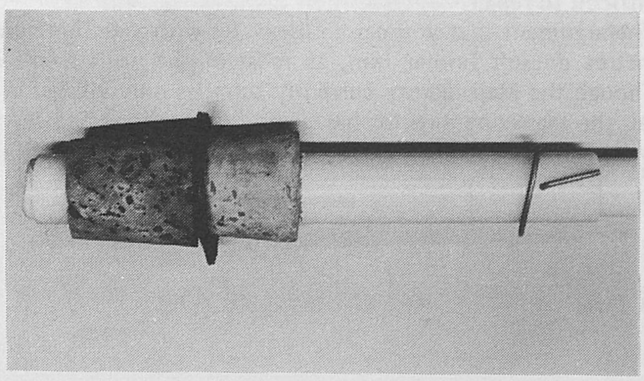


Diagram of the suction pump

A model of a suction pump made of PVC tubes.

The piston can be made from corks, a flexible rubber flap cut from the inner tube of a bicycle tire and PVC conduit. The suction flap must be fitted into the tube with its edges curled upwards.



A piston for the suction pump. Note how it differs from the piston of the displacement pump on page 29; the corks are reversed.

the suction pump

Assignments

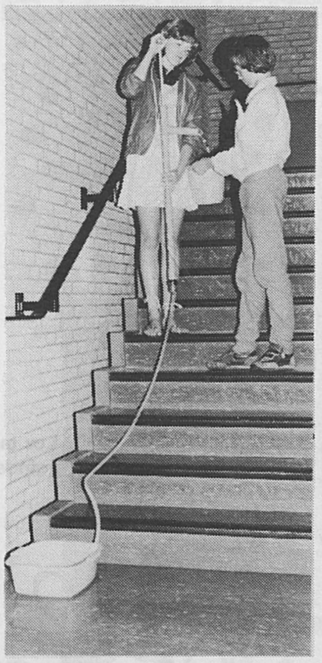
1. Carry out the assignments given in 'Instruction for working groups' on page 24.

Below you will find some additional notes on some of the assignments which have to be carried out using your model pump.

2. Explain to one another how the model pump works. This is a good way of preparing you demonstration to the class. You'll find more information about the suction pump on page 47.

3. How long does it take to pump up 10 litres of water with your model? (Pump steadily and don't hurry) How long do you think it's going to take with a real suction pump inKisima? For how much of the day will the pump be in use if all the inhabitants of the village use 10 litres of water a day?

4. From what depth can your model pump up water? The photo shows one way of finding this out.



Think how you could modify the pump in order to be able to raise water from a greater depth.
Could you improve the pump in such a way that it could raise water from a depth of 15 metres?

the rope pump

WORKING GROUP 4 The rope pump, adaptable to every situation

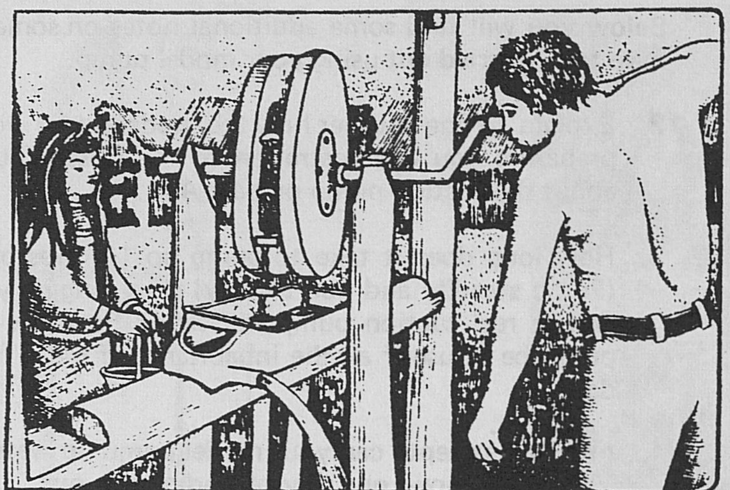
LA "BOMBA DE SOGA" PARA POZOS DE AGUA

Translation from the Spanish
The rope pump: a rope in a pipe with water.

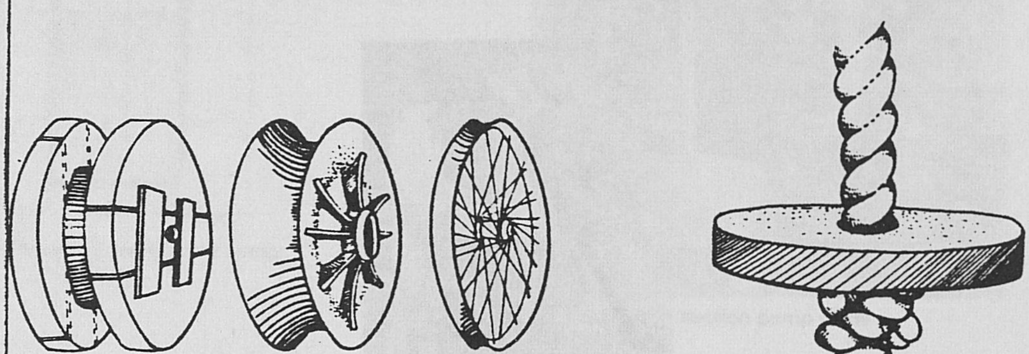
With the help of Tom Aarden, the village of Shipibo de San Francisco (Pucallpa) has found a solution to the problem of the drinking water supply. A pump has been installed that can provide over 200 people with water.
The pulley can be made from a wagon wheel, a bicycle wheel or a wooden wheel.

Note how the discs are cut out of an inner tube.

The discs must be slightly bigger than the diameter of the plastic pipe.

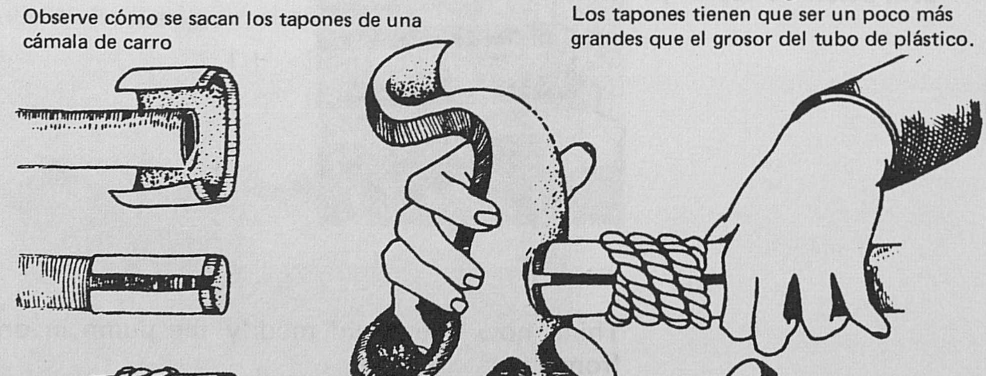


La comunidad Shipibo de San Francisco (Pucallpa), con apoyo de Tom Aarden, ha solucionado su problema de agua potable instalando una bomba de soga que abastece a más de 200 personas.



Observe cómo se sacan los tapones de una cámala de carro

Los tapones tienen que ser un poco más grandes que el grosor del tubo de plástico.

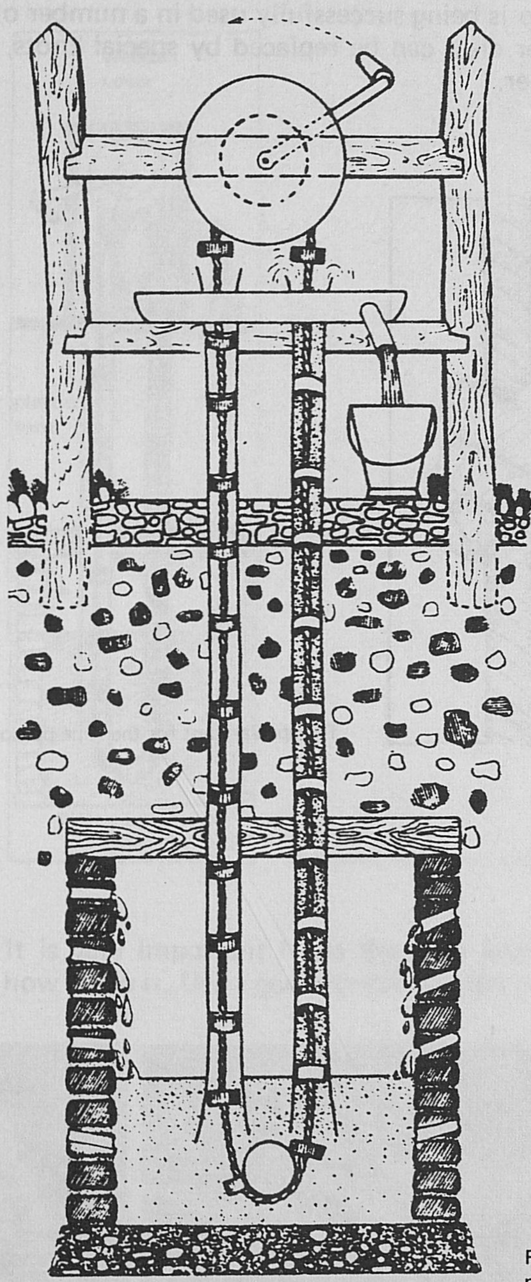


the rope pump

The water found in the forest is usually contaminated. That is why we wanted some means of providing the people with water that would not endanger their health. A pump with a rope passing through a pipe is the best solution because it is easy to make and not expensive. A big advantage of having a pump is that you no longer need to carry water from a distance.

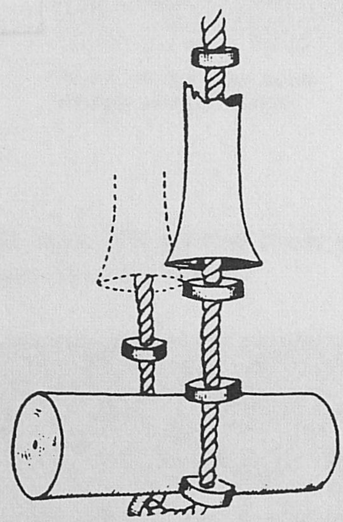
What do you need
A wheel to act as a pulley, rope (nylon), two plastic pipes one inch in diameter, a thick iron pipe, wood, cement and especially ingenuity and the enthusiasm of the whole village.

Heat the plastic pipe at both ends to form a funnel.



En la selva, el agua generalmente está contaminada. Por eso se buscó un sistema que permita el consumo humano sin peligro para la salud. La bomba de soga conectada a un pozo fue la mejor solución, pues es de fácil construcción y no demanda mucho gasto. Además, ahorra largas caminates cargando agua.

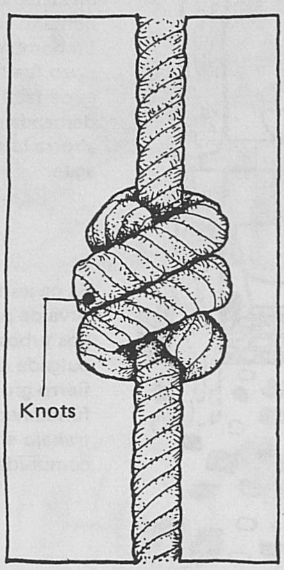
Se necesita: una rueda que sirva de polea, una soga (nylon), dos tubos de plástico de una pulgada de diámetro, un tubo de fierro grueso, maderas, cemento y, fundamentalmente, ingenio y trabajo entusiasta de toda la comunidad.



Recaliente el tubo de plástico en las terminales para darle el acabado de "embudo".

the rope pump

We found this article on a rope pump in a South American magazin on village development. Rope pumps originated in the developing countries where you often come across them in the form of bucket or chain pumps. This rope pump has been improved by a team of engineers in the Netherlands and is being used in many countries. The article reprinted here describes the situation in a village in Peru where the villagers made the pump themselves. The rope pump is being successfully used in a number of African countries as well. The rubber discs can be replaced by special knots, which simplifies the pump even further.



The special knot for the rope pump.

the rope pump

A model of a rope pump

To make a model rope pump you need:
plastic rope, PVC conduit of a certain diameter, a few sticks and tins or round pieces of wood, funnels or buckets.

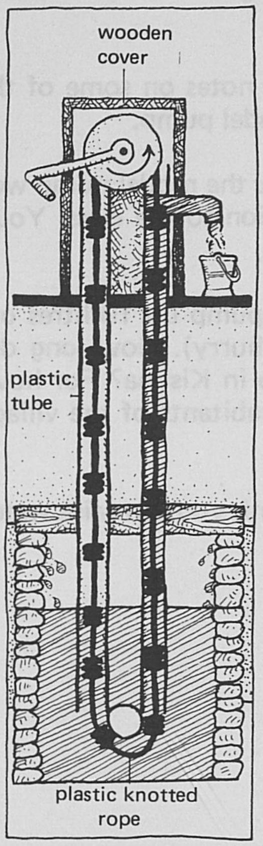
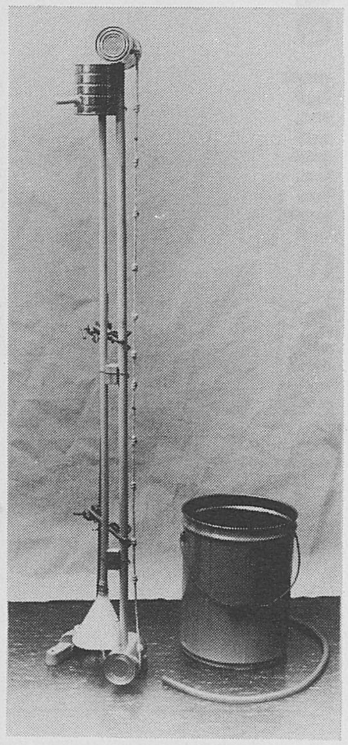
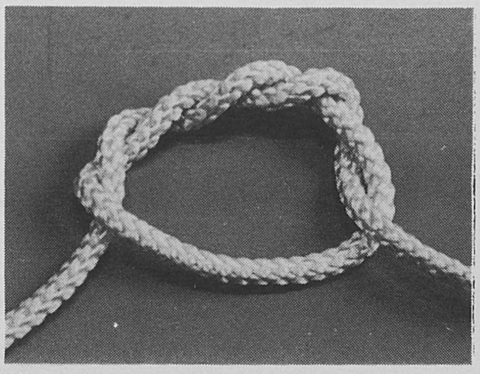


Diagram of the rope pump

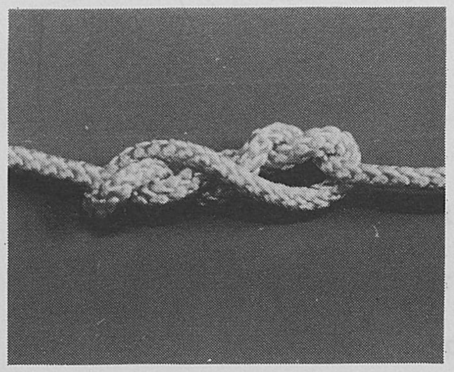


Model of the rope pump without wheel or handle.

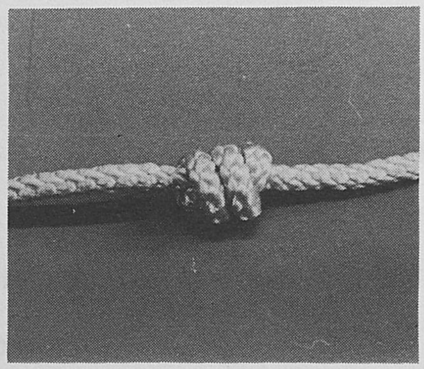
It is very important to tie the right knots in the rope; the photos show you how to do it. Use a good length of rope as a lot goes into the knots.



Make three loops in the rope.



Carefully pull them tight.



There is the knot.

the rope pump

You can join the ends of the rope by holding them over a flame, pressing them together and letting them cool.

Assignments

1. Carry out the assignments given in 'Instruction for working groups' on page 24.

Below you will find additional notes on some of the assignments which have to be carried out using your model pump.

2. Explain to one another how the model pump works. This is a good way of preparing your demonstration to the class. You'll find more information about the pump on page 50.

3. How long does it take to pump up 10 litres of water with your model? (Pump steadily and don't hurry). How long do you think it's going to take with a real rope pump in Kisima? For how long will the pump be in use every day if all the inhabitants of the village use 10 litres of water a day?

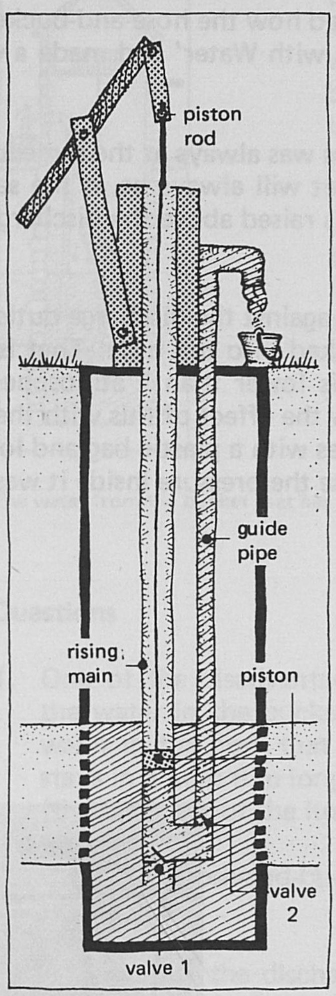
4. To what height do you think you can raise water with a rope pump? Give reasons for your answer.

3 how the pumps work

contents

how the pumps work

3-1 HOW THE DISPLACEMENT PUMP WORKS



The displacement pump works with a submerged piston. When the piston rises, water flows into the cylinder; when the piston is moved downwards, the water from the cylinder is forced upwards.

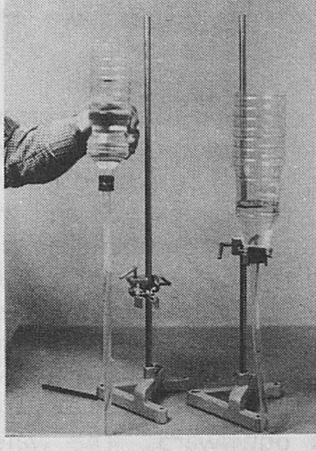
We'll now examine this more closely for each stroke of the pump. When the handle is pushed down, the piston moves upwards and the pressure of the water under the piston drops slightly, enough to open valve 1 and close valve 2. Water flows in through valve 1. When the handle is raised, valve 1 is closed and valve 2 opens because the piston is pushed downwards. The water begins to rise in the rising main. The higher it rises, the more difficult it becomes to force it further upwards; greater effort is needed to pump, especially to push the handle up. The valves will begin to leak as the pressure of the water at the bottom of the rising main becomes greater, so that water will also be forced up past the piston. The height to which the water can be pumped is determined by the degree to which the valves leak.

Questions

1. Good displacement pumps can pump up water from a depth of 30 metres. The pressure that must be exerted on the water by the piston is quite considerable: 3 atmospheres extra pressure. Explain this.
2. Why is the piston rod in a displacement pump easily damaged?
3. Will there by any difference in the pressure on the valves between a wide rising main and a narrow one? Give an explanation.

3-2 HOW THE HOSE-AND-BUCKET PUMP WORKS

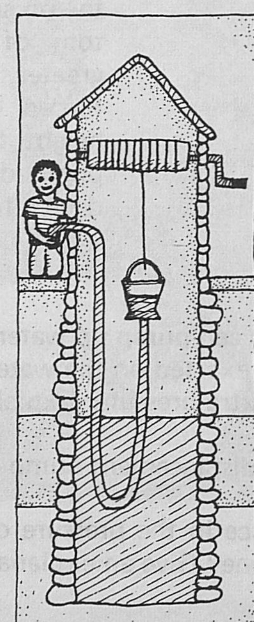
You will have discovered how the hose-and-bucket pump works if you did the PLON theme 'Working with Water' and made a water level with bottles and a length of pipe.

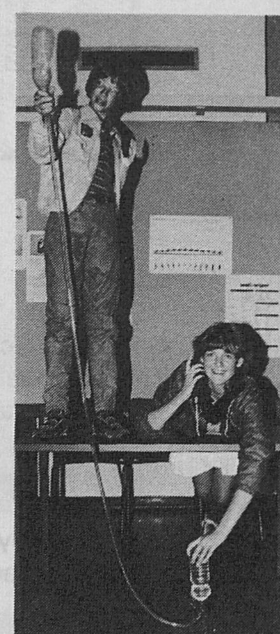


The bottle water level

The water in the bottles was always at the same level. In exactly the same way the water in the bucket will always be at the same level as the water in the hose until the bucket is raised above the discharge outlet, when the water will run out.

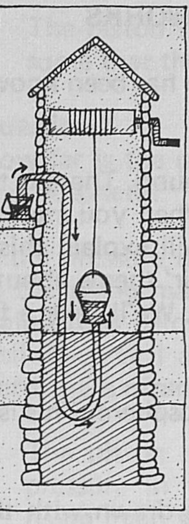
If you put your finger against the discharge outlet and then lower the bucket, you'll feel it being sucked into the hose. That is because the pressure of the water on your finger is lower than 1 atmosphere (the pressure of the air at sea level). You also saw the effect of this with the bottle water level when you closed one of the bottles with a plastic bag and lowered the other. The (plastic) bottle crumpled because the pressure inside it was reduced.





Note the crumpled bottle

how the pumps work



Just as your finger was sucked into the pipe when the bucket was lowered, so will the water be if you leave the end of the hose in a full bucket. The water will be sucked out of the full bucket and into the bucket connected to the hose. This process will continue until the water level in the bucket has dropped to the point where air is being sucked into the pipe. This is known as *siphonage*.

(People who have aquaria often siphon water out of them in this way. They hang a length of hose pipe full of water in the aquarium with the other end in a bucket at a lower level. The pipe must be full of water or the siphon doesn't work.)

The water from the bucket that has just been filled is sucked back into the hose by siphonage.

Questions

1. One of the disadvantages of the hose-and-bucket pump is that not all of the water in the bucket inside the well can be discharged. There is always water in the hose that cannot be pumped out. Calculate how much water stays in a hose 6 m long with a jet of 1 cm.
(the diameter of the hose is $\pi\ r^2 = 3.14\ cm^2$).
2. Could the hose-and-bucket pump be used for deep wells? Give an explanation.
3. If you close the discharge outlet with a cork before lowering the bucket, the water in the hose won't run back into the bucket as it is lowered.

   a. Explain why the water no longer flows back into the bucket.

   b. Explain why a little of the water does flow back if the bucket is lowered more than 10 metres.

   c. When the bucket is raised above the discharge outlet, the cork is removed. What is the maximum amount of water that can now flow out of the discharge outlet?

3-3 HOW THE SUCTION PUMP WORKS

The principle of the suction pump has been known for a long time. Dutch village pumps are suction pumps.

The piston and valve are above ground. There is therefore air under the piston when the pump is not working. When you start pumping you remove this air which is replaced by water. We will explain this in a number of steps, using what you learnt in the 'Living in Air' theme about the change in pressure when you compress air or let it expand. We'll take a few figures to illustrate what we mean.

The pressure of air is about 1 atmosphere. This is practically equivalent to the pressure of 10 metres of water.

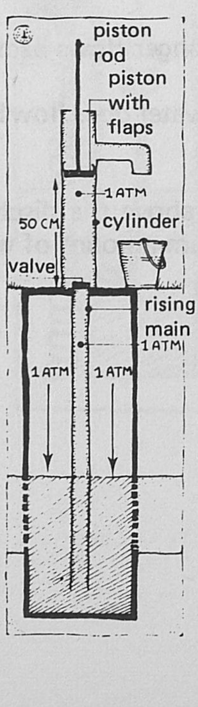
a. In figure 1 the pump has been drawn with the piston in the highest position. The water in the suction pipe is at the same level as the water in the well. The handle has been omitted from the drawing.

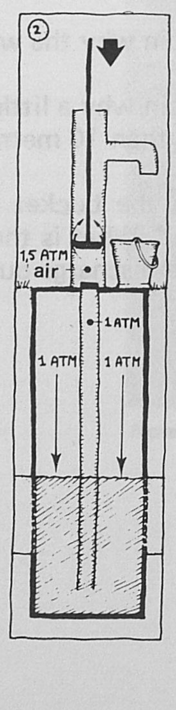
b. The piston is forced down. The pressure under the piston rises and the valve is closed.

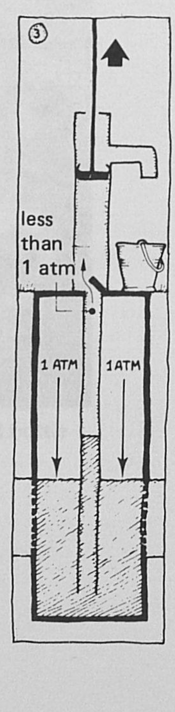
If the pressure in the cylinder is too high, the flaps of the piston will be pushed up slightly, allowing air to escape. We assume that this pressure is 1.5 atmosphere. See fig. 2.

Question 1
How far is the piston from the bottom of the cylinder when the air first starts escaping round the flaps?

Question 2
How high is the pressure under the piston if the piston stops 10 cm above the bottom of the cylinder?







c. The piston stops at 10 cm above the bottom and then rises again. We assume that the flaps cease to allow air to escape.

Question 3

How far is the piston from the bottom if the pressure in the cylinder is again 1 atmosphere?

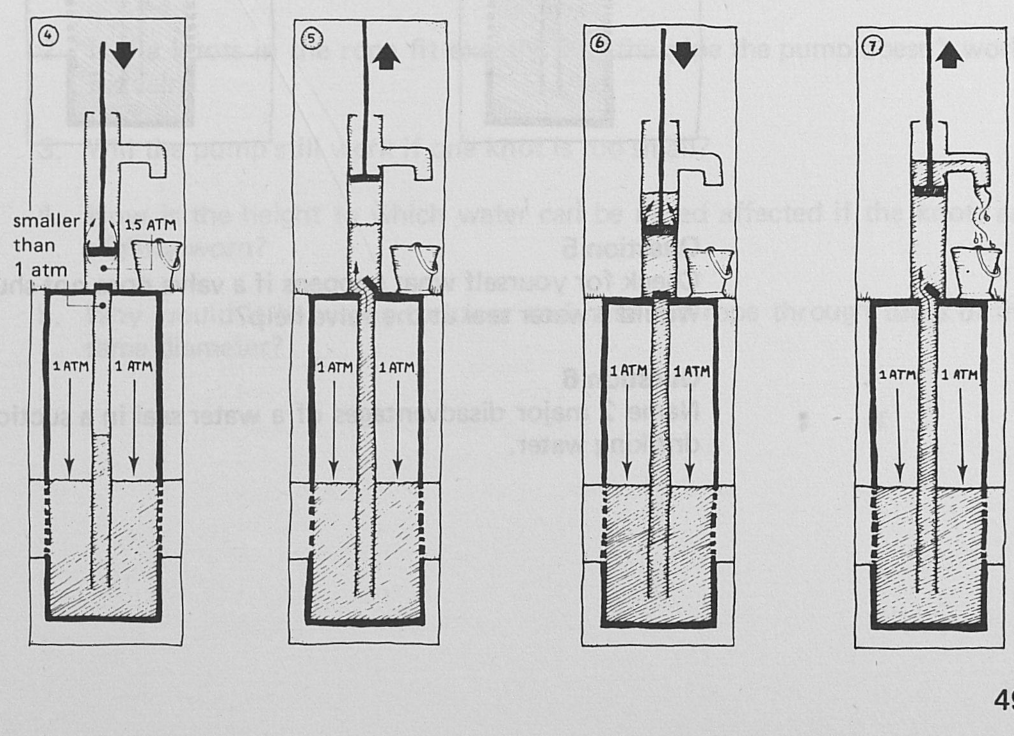
If the pressure drops below 1 atmosphere, the valve is pushed open by the air in the rising main and air flows into the cylinder. The pressure in the rising main drops below 1 atmosphere. The pressure of the air on the water in the well stays at 1 atmosphere so that the water in the rising main is forced upwards (it is often said to be 'sucked upwards'). See fig. 3.

d. The piston arrives at its highest position and descends again, causing the pressure in the cylinder to increase. The valve shuts. The water in the rising main stays at the same level and air is again forced out of the cylinder (see fig. 4). This is repeated, with the result that the water in the rising main rises higher.

e. After several strokes of the pump the water rises so high that it passes the valve and enters the cylinder. The last of the air is forced out of the cylinder. See fig. 5.

f. When the piston is pushed down again, the water is forced past the flaps and rises above the piston. See fig. 6.

g. The water above the piston flows out of the discharge outlet when the piston is moved upwards. New water under the piston is forced (sucked) upwards through the valve by the pressure of the air on the water in the well. See fig. 7. If you keep on pumping, water will continue being dis-

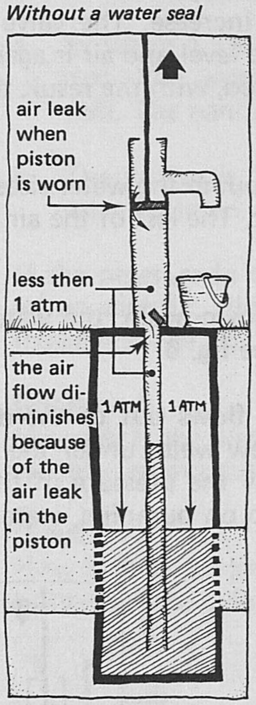


charged from the pump as long as the lower end of the rising main remains under water.

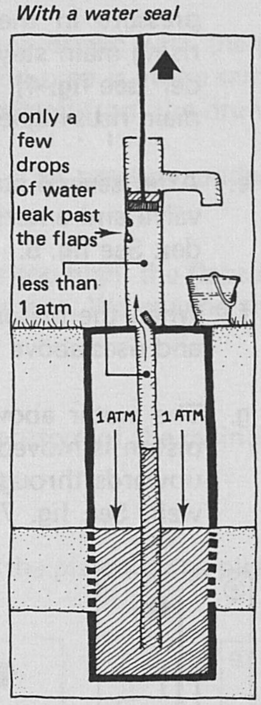
Question 4
Why is it not possible in theory to pump up water from a depth of more than 10 metres with a suction pump?

The washers of the piston will wear out from being moved up and down along the wall of the cylinder. If the washers are worn, air will enter the cylinder from above when the pressure there drops below 1 atmosphere, so that the water will not rise in the rising main. You can prevent air from entering by pouring water on the piston which will press the flaps against the wall of the cylinder (water seal).

Without a water seal

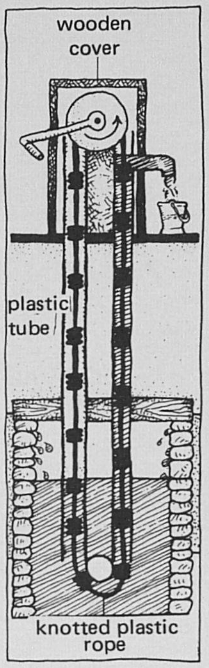


With a water seal



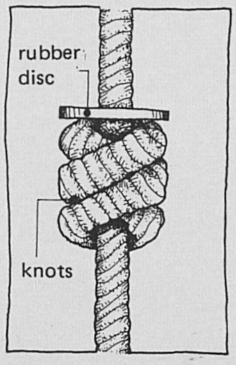
Question 5
Check for yourself what happens if a valve does not shut properly. Would a water seal at the valve help?

Question 6
Name 2 major disadvantages of a water seal in a suction pump used to supply drinking water.



3-4 HOW THE ROPE PUMP WORKS

When you start turning the handle of a rope pump, the knots raise the water. Only a small amount of water will leak past each knot because the rope fits tightly into the tube.
This creates a water seal! (See also 3-3). The water between the knots lower down must therefore be lifted as the knots rise. If it weren't, there would be a vacuum between two knots because no air can get in, there being a water seal above. But it is impossible to have a vacuum between two knots, which is why more and more knots will bring up water until it comes out at the top.
The greater the depth from which you raise water, the greater the pressure on the lowest knots, and the more water will be lost through leakage.
Only at a great depth will the leakage downwards be equal to the amount of water to be raised, which means that the pump can no longer work.



Questions

1. Some-one is trying out a home-made rope pump. The pump can raise water from a depth of 6 metres. He fixes a rubber disc cut from an inner tube on the top of each knot. The discs fit into the tubes. He sees that the pump can now raise water from a depth (or to a height) of 12 metres. Explain why the pump now works better.

2. If the knots in the rope fit exactly into the pipe the pump doesn't work. Explain.

3. Will the pump still work if one knot is too small?

4. How is the height to which water can be raised affected if the knots are slightly worn?

5. Why would it be wrong to lower and raise the rope through tubes of the same diameter?

4 texts for reference and reading

texts for reference and reading

contents

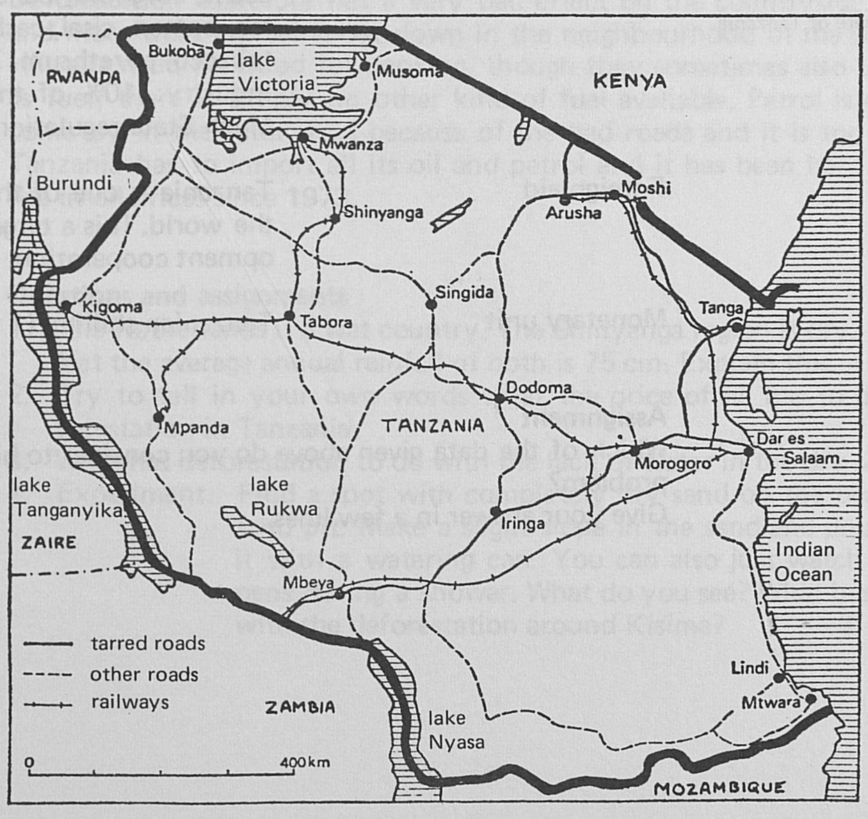
TEXT 1

Tanzania

Kisima is situated in the region round the town of Shinyanga in the north west of Tanzania. Tanzania is a country on the east coast of Africa. It is slightly south of the equator and is thus a tropical country.
Look up Tanzania on a map of Africa.

Some data on Tanzania

	Tanzania	*Netherlands*
Surface	937,000 km	33,000 km
Population	17,000,000 (1980)	13,500,000
Population density	16 per km^2	400 per km^2
Annual population increase	2.7% (1971-1973)	0.77%
Percentage of population in towns	7 to 8%	51%
Percentage of children who attend primary school	48% (1973)	100%
Percentage of children who attend secondary school	8% (1973)	100%
Adult illiteracy	75%	4%
Number of inhabitants per doctor	25,000	3,000
Average life expectation	41 years	70 years
National income per capita	*f* 350,– (1973)	*f* 11,500,–



Map of Tanzania showing railways, tarred and dirt main roads.

Tanzania

President Nyerere of Tanzania.

Climate (see also Text 2)	Average annual temperature in Dar-es-Salaam is 25.7° C, in Mwanza on Lake Victoria (at 1245 m) 22.7° C. Rainfall: Only one third of the country has an annual rainfall of more than 750 mm. Rainy season from November to the end of May, in the north a short rainy season November/December and a longer one from March to May.
Form of government	Tanganyika independent since 1961, Zanzibar (including island of Pemba) since 1963, united in 1964 to form the United Republic of Tanzania.
Capital	Dar-es-Salaam. Dodoma designated future capital.
Language	Swahili. English is understood.
Economy	Agriculture accounts for 37.6% of the gross national product; 91% of the population engaged in agriculture. Largely subsistence farming. Chief products: maize, millet, cassava, beans, sorghum, bananas, rice. Cash crops: coffee, cotton, sisal, cashew nuts, groundnuts, tea, tobacco, pyrethrum. Zanzibar: cloves, copra. Industry: 10% of the gross national product. Much State regulation.
Foreign aid	Tanzania is one of the 25 poorest countries in the world. It is a target country in Dutch development cooperation.
Monetary unit	Tanzanian shilling (1 tsh = *f* 0.24).

Assignment
Which of the data given above do you consider to have a bearing on the water problem?
Give your answer in a few lines.

TEXT 2 the climate of Tanzania

The region around Shinyanga is very dry. The average annual rainfall is 75 cm but in some years it is only 50 cm and in others 100 cm. In the former case this means that there is a severe drought, in the latter that there are floods.
The Netherlands also has an average annual rainfall of 75 cm which varies from between 65 and 85 cm but is seldom less or more. The average annual temperature in the Netherlands is 9.3° C (taking day and night, summer and winter temperatures). In the Shinyanga region the average temperature is 23° C. If there were a spot where the ground was always damp, $1\frac{1}{2}$ metres of water would evaporate in the course of a year. But only 75 cm of rain falls, so there is no more than 75 cm of water to evaporate. This means that for part of the year the soil is bone dry.
Rain falls in the rainy season from November to the end of May. During this time the soil is damp and plants and trees can grow, crops must be sown, they must grow, ripen and be harvested. Not much can grow in the dry season and many trees lose their leaves. Water which does not evaporate in the rainy season sinks into the soil where it seeps slowly under the ground through permeable strata (such as sand) to the rivers. But where no plants or trees grow (because of deforestation) the soil is bone dry. The water cannot penetrate the cement-like surface and streams directly towards the rivers, carrying a great deal of topsoil with it (erosion or the destruction of the soil). The rivers are not deep enough to carry off a large amount of water in a short time and overflow their banks. No water is absorbed by the soil, so that in the dry season the rivers will not be fed by underground streams and will dry up too.
Deforestation therefore has a very bad effect on the countryside. Yet more and more trees are being cut down in the neighbourhood of the villages. The villagers need firewood for cooking, though they sometimes also use manure as fuel; there is simply no other kind of fuel available. Petrol is difficult to come by in the rural areas because of the bad roads and it is too expensive. Tanzania has to import all its oil and petrol and it has been hard hit by the rise in oil prices since 1973.

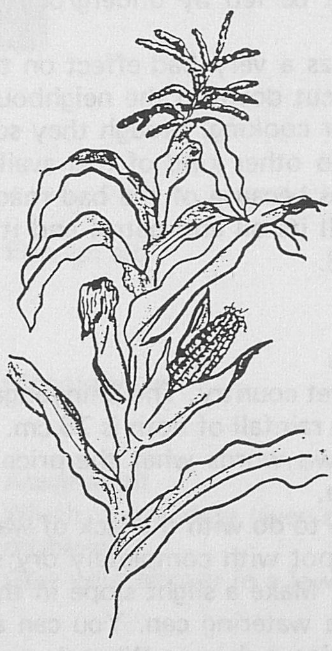
Questions and assignments

1. The Netherlands is a wet country. The Shinyanga region is dry. Yet the average annual rainfall of both is 75 cm. Explain this.
2. Try to tell in your own words what the price of oil has to do with deforestation in Tanzania.
3. What has deforestation to do with the lack of water in the dry season?
4. Experiment: Find a spot with completely dry sand on the beach or in a sand pit. Make a slight slope in the sand and pour water on it with a watering can. You can also just watch what happens during a shower. What do you see? What has this to do with the deforestation around Kisima?

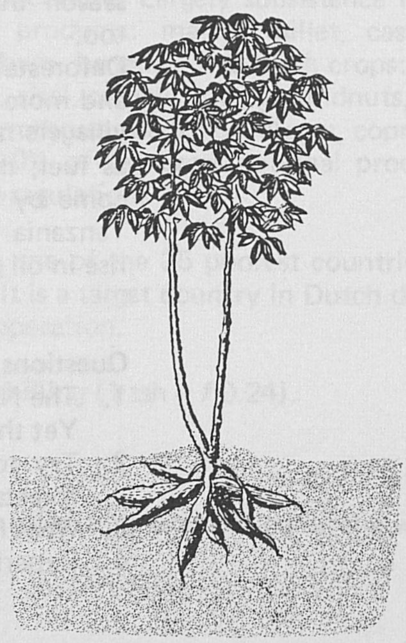
TEXT 3 life in a Tanzanian village

Villagers work the land with hoes

The population of most villages in Tanzania lies between 200 and 5000 inhabitants. The villages consist of mud huts thatched with dried grass. The men are members of a cooperative or are unemployed. The Tanzanian government is trying to unite farmers in cooperatives for the production of cash crops such as cotton, sisal and coffee. These crops are exportable and enable Tanzania to import oil, building materials and machines. The cultivation of the family plot of ground is women's work. So is fetching water, collecting wood and the usual household chores. Cooking is done outdoors. The staple diet is maize, from which a sort of porridge known as 'ugali' is made and eaten with vegetables. Cassava and sometimes rice are also on the menu. The soil is cultivated with the hoe, which is used to loosen the topsoil; the underlying humus is left undisturbed and is thus protected against dehydration and decomposition. The land is not particularly fertile. Good harvests can only be counted on if the rains start early in November and are abundant. The villagers don't start sowing until they are certain that the rain has really set in, otherwise the seed is wasted and the harvest bound to fail. If the rains start late the growing season is too short for a good harvest.

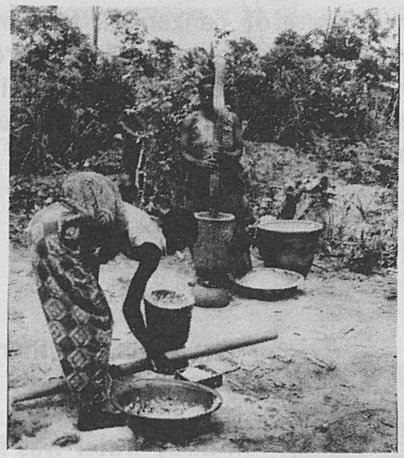


Maize



The cassava plant has a good yield and can grow under fairly unfavourable conditions. The tubers are the part of the plant that is eaten

life in a Tanzanian village



Pounding maize

So the villagers often go hungry. Chronic undernourishment undermines their resistance to disease, so that they are more likely to contract diseases such as cholera and diarrhoea which are caused by contaminated drinking water.

The Chief is the traditional leader of the village, but since Tanzania gained its independence in 1961, the influence of the representative of the country's only political party, TANU, has increased considerably, and it is he who keeps up contact with the regional authorities in the towns. The village is administered by a village council of 8 men, including the Chief and the TANU representative.

In the dry season a bus occasionally arrives from the nearest town enveloped in an enormous cloud of dust. The roads are dirt roads and full of potholes. Many villages in Tanzania are nowhere near even dirt roads and never see a bus. In the rainy season the roads are impassable because of the mud and pools of water, so the bus 'service' is suspended. All this makes contact with the town very irregular, and it is difficult to transport anything from the towns to the villages.

Questions and assignments

1. What information in this text do you consider to have a bearing on the water problem?

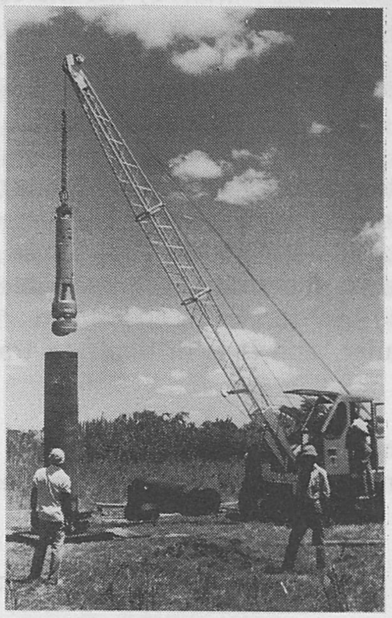
2. Give two reasons why the harvest in Tanzania sometimes fails.

TEXT 4

the pump that failed

The aim of President Nyerere of Tanzania is to provide all villagers with good drinking water at a maximum distance of $1\frac{1}{2}$ km from their homes. By Dutch standards this is incredibly inadequate but if the aim is achieved it will mean tremendous progress for Tanzania. Millions of Tanzanians still draw water from dirty pools, some of which are at a distance of 5 kms from their homes. But it is not easy to achieve. Ten years ago a pump was installed in the village of Wanaki but it hasn't worked for a long time...

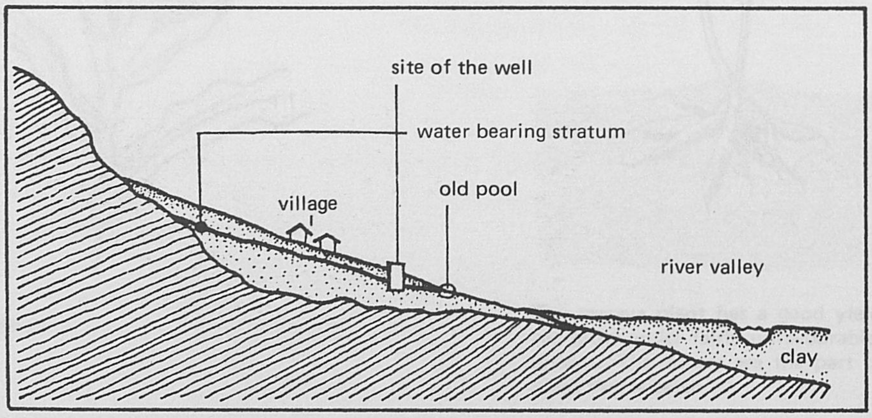
Here are some of the reasons..



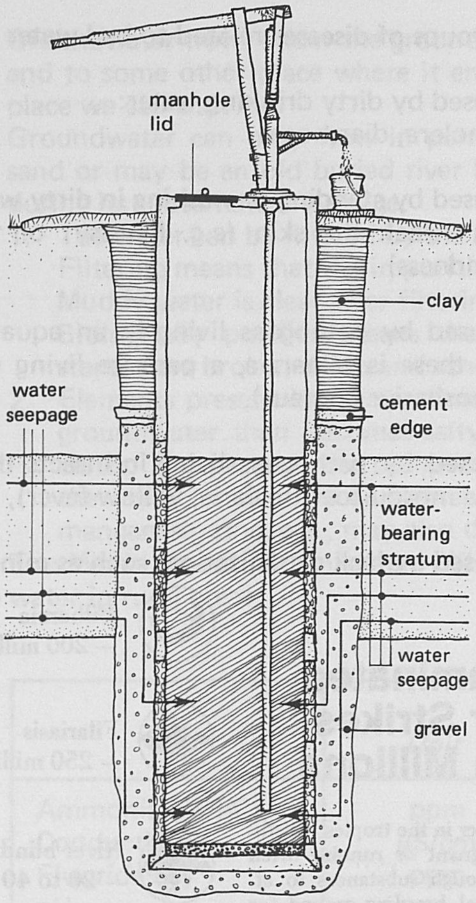
A large crane digging a well.

Ten years ago there was a severe drought in Wanaki. The pool from which the villagers had always drawn their water was dry. Only muddy water was found in the holes dug in a dry river bed 4 kms away. An aid programme was set up by an international organisation for the areas in Tanzania that were hit by the drought. Wells were dug where there was groundwater at places accessible to large machines.

Wanaki is situated on a road. Aerial photos revealed the presence of groundwater near by. A land-rover arrived with a light mechanical drill, and a number of exploratory drillings were carried out to locate the exact position of the groundwater. A water-bearing sand stratum was found at a distance of 1 km from the village. The water was fortunately not brackish but fresh and of reasonably good quality.



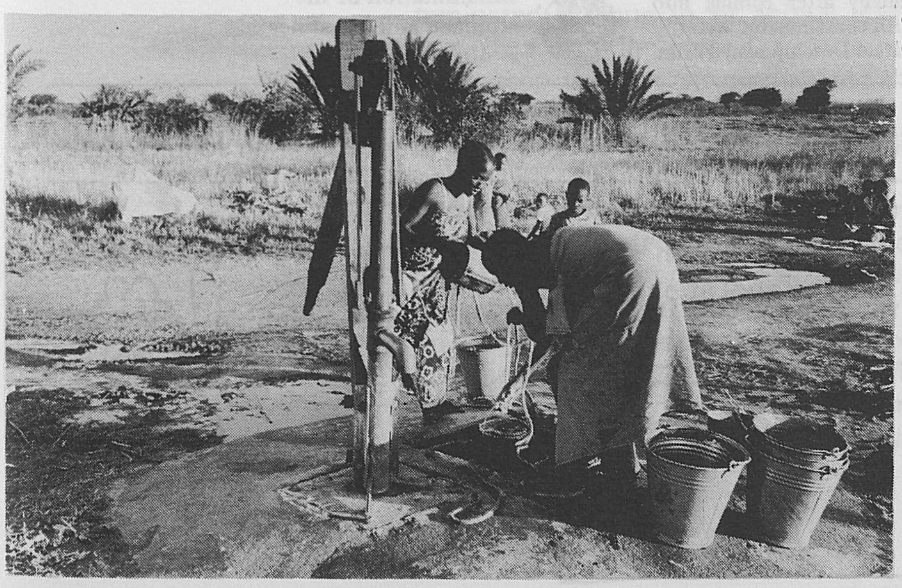
the pump that failed



This is how water seeps from the water-bearing stratum into the well

The groundwater present was also replenished at a fair rate so it was decided to dig a well there. A enormous crane with a special grab dug the well in record time. A truck delivered concrete well-rings at the site. A pump was installed, everything was disinfected and the pump was ready for use. All the machines disappeared and peace and quiet returned to the village.

There was enough water again! The women were delighted that they only had to walk 1 km instead of 4 to fetch water. But the international organisation had had no time to tell the villagers about the importance of clean water and of keeping the direct surroundings of the pump clean. There were other villages waiting for pumps, so they had to move on quickly. Nobody in the village knew anything about the pump, how it worked, what maintenance it needed or how to repair it. The pump worked without a hitch for a year. Practically all the villagers fetched their water there, did their washing and washed their children at the pump. But then it broke down. Nobody could repair it, and as there were no spare parts, *Maji* couldn't do anything either. The well is still being used, but the water is being drawn up with a bucket on a rope. That takes a great deal of time, and what is more, the ground water gets dirtied.



TEXT 5

diseases caused by bad water

There are 5 groups of diseases related to bad water and sanitation.

1. Those caused by dirty drinking water: typhus, cholera, diarrhoea
2. Those caused by standing or washing in dirty water: pathogens attack the skin (e.g. leprosy) or the eyes (trachoma which causes blindness).
3. Those caused by pathogens living in an aquatic animal. The most widespread of these is bilharzia, a parasite living on a certain type of water snail (Planorbarius corneus).
4. Those caused by pathogens living in insects that breed in or near water, or instance mosquitoes (malaria, yellow fever), or flies (river blindness).
5. Those caused by lack of sanitation, such as miner's worm.

'Volkskrant' (a Dutch daily) 11.11.80

Contaminated Water Strikes Down Millions

Surface water in the tropics, whether it is stagnant or running often contains enough substances to afford an ideal breeding ground for organisms which directly cause disease, or for insects and animals which transmit diseases to human beings.
The table below gives a number of diseases and a rough indication of the number of people who contract them annually after coming into contact with contaminated water.

Source: Development Forum


Bilharzia
– 200 million


Filariasis
– 250 million


River blindness
– 20 to 40 million


Malaria
– 160 million


Inflammation of the stomach and intestines
– 400 million

The Magician of Fop

by Brant Parker en Johnny Hart

TEXT 6 the quality of groundwater

Groundwater flows under the ground from the place where it has fallen as rain and to some other place where it emerges from the ground again. The second place we call a *spring*.

Groundwater can only flow in permeable strata, which may consist of fine sand or may be an old buried river bed. Two things can happen to the water during its subterranean passage:

1. The water can be filtered by the sandy stratum and biologically purified. Filtering means that the impurities remain lodged in the sand. Muddy water is clear after filtering. Biologically purified means that germs, organic refuse and similar substances are broken down and rendered harmless by bacteria in the soil.
2. Elements present in the sand may be dissolved in the water. In Tanzania groundwater then becomes salty itself and is not much good as drinking water. The parts of the pump that are made of iron rust more quickly if the water is salt. Other elements such as compounds of fluoride, iron, manganese, zinc, etc., may also dissolve.

The World Health Organisation (WHO) has laid down standards for drinking water in rural areas.

	Unit	*WHO desired standard*	*acceptable*
Ammonia ($NH4^+$)	ppm	0.5	1.0
Conductivity	µS/cm	750	2000
Fluoride (F)	ppm	1.0	8.0
pH		7.0 - 8.5	6.5 - 9.2
E. coli	number	0	0

Ammonia and bacteria such as E. coli are found in water that has been contaminated by human or animal waste matter. Such pollution occurs when there is a watering place for cattle near the well from where urine and dirty water seep through the ground into the well. If the distance is big enough, the sandy stratum will be able to purify it biologically. It is bad for drinking water if the ground around the well is muddy and especially if cattle can come and go freely.

Electrical conductivity is an indication of the total quantity of dissolved substances in the water. In Tanzania it is often higher than the desired level.

The fluoride content in Tanzania is often much higher than it should be. Sometimes it is even higher than the acceptable maximum, which is already on the high side and is therefore only temporarily applicable. If the WHO standards for fluoride were applied, nearly all the wells in Tanzania could be declared unsafe. Too much fluoride makes teeth and bones too hard and they become brittle. Teeth decay more quickly and the likelihood of broken bones increases.

the quality of groundwater

(In the Netherlands many dentists consider that there is too little fluoride in the drinking water. This means that the enamel coating the teeth is not hard enough and holes develop easily. These dentists want fluoride added to the drinking water).
Tanzania hopes to be able to conform to WHO standards in future. But the first problem is to provide everyone with drinking water, even if the quality is not quite up to standard.

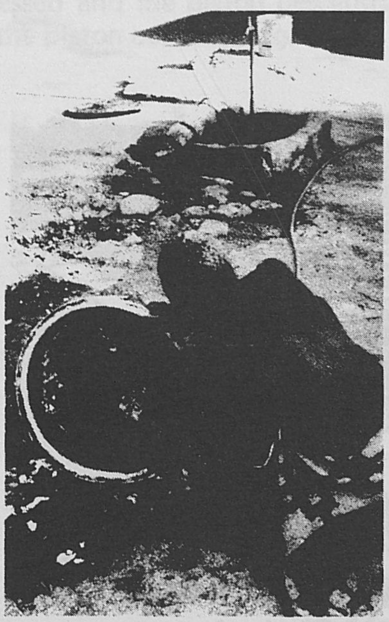
TEXT 7

WATER

Tanzania hopes to solve its water problems by mounting ambitious projects

It is a familiar sight in the rural areas of Tanzania: women walking 10 to 15 kilometres every day with a bucket or jug on their heads to fetch water from a spring or a polluted river. This water is drunk, food is cooked in it and it is used for washing.

Ninety per cent of Tanzania's population of 14 million live in the rural areas. Eighty per cent of these people have no drinking water, which means that measures must be taken for a good 10 million men, women and children.
President Julius Nyerere's government aims to provide the whole rural population with a better water supply in the coming 10 to 15 years. Life in the rural areas would become less of a handicap, the urge to trek to the big towns would wane, the incidence of diseases such as cholera, dysentry and bilharzia would decrease, and it would be possible to irrigate the dry fields.
The improvement of the water supply is being tackled in various ways by the Water Supply Department in Tanzania, commonly known as MAJI, the Swahili word for water. MAJI has a wide variety of projects, many of which are being carried out with technical and financial aid from abroad. One of the projects involving Dutch funds and expertise is situated in the area around the town of Shinyanga. Shallow wells are being dug in the villages with the help of the villagers themselves. It is essential they learn how the wells work so that they can carry out the maintenance themselves once the project has been completed. If this quite simple approach works out in practice, it could be used in other parts of the country as well.
Another project in the neighbourhood of Korogwe in the eastern province of Tanga is the construction of a water purification plant with West German Financial aid. In a year's time it should be supplying clean water to 100,000 people in an area of 7,000 km². The whole project costs about 25 million



A Tanzanian women cleans a basin at the village pump.

guilders. From an economic point of view this is unprofitable, but the Tanzanian government considers the project worth-while in social terms.

Water purification

There is a larger water purification plant near the capital, Dar-es-Salaam. The man concerned with the preparation and the construction of the plant is Rob van der Plas, a Dutch volunteer. 'The point at which we draw water from the river is five metres higher than the plant. The great advantage is that we don't need to pump and can let gravity do the work for us,' said Rob. The project was started in the summer of 1975 and it is planned to complete it at the beginning of 1978, provided there are no hitches. There is already a delay of a year, due mainly to the chronic shortage of cement throughout Tanzania. The only cement factory at Dar-es-Salaam is often unable to meet the enormous demand.
As the water enters the plant from a pipe, the iron is removed first. It then passes through a number of filters to remove sand and other impurities. Then the water is chlorinated to kill the remaining bacteria. Rob explained that it is an extremely simple system but that it requires maintenance. The filters, for instance, must be cleaned

regularly. There is a small laboratory at the plant so that the quality of the water can be permanently monitored. The water is carried through a network of plastic and steel pipes to the consumers. Only those who want a tap in their houses are required to pay for the water; water collected at the village tap or pump is free.

Ambitious

A colossal sum of money is needed to carry out the ambitious plans of the Tanzanian government. There are probably cheaper ways of setting about it, but MAJI is not interested in simple solutions. Tanzanian civil engineers are already looking down their noses at the Shinyanga district well project, and their attitude to an experimental project at Lake Victoria is even more contemptuous. In the village of Kayenze on Lake Victoria a Dutch volunteer designed a system for carrying water through bamboo pipes and hollow three trunks. The villagers and a Tanzanian engineer considered it feasible and put it into operation. MAJI wouldn't have anything to do with 'this crazy do-it-yourself stuff' and it took quite an effort to get government support for the project. Even after completion the authorities weren't exactly cooperative. Last year the water supply had to be discontinued for a while because there was a shortage of fuel for the pump that draws water from Lake Victoria. The allocation of fuel was not a priority in the eyes of the local authorities.

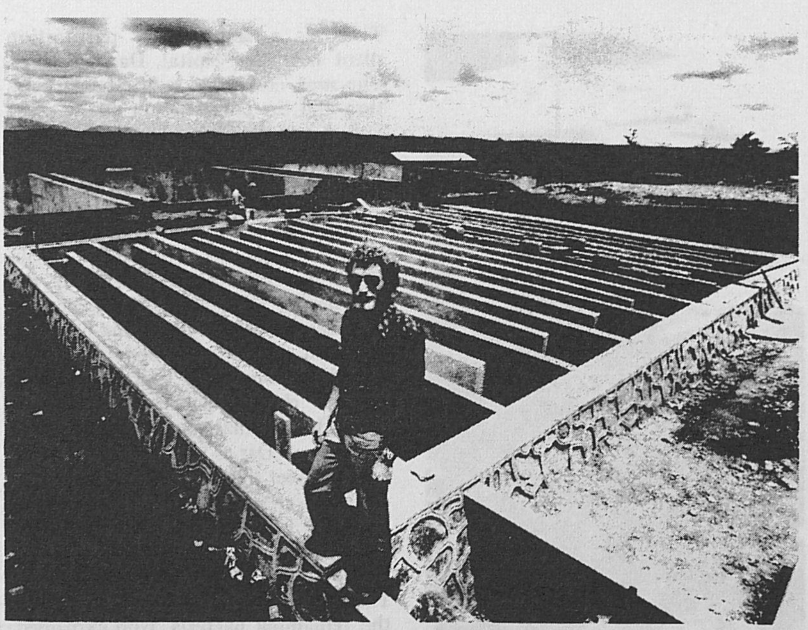
Bilharzia

The water in Keyenze is intended mainly for irrigating the fields but it is also used as drinking water. This is perhaps rather strange as the water of Lake Victoria is known to be infected with the dreaded Bilharzia parasite. But the local population reasons 'We'd rather have water and bilharzia, which so many people have got anyway, than no water at all.'

With a reasonably good irrigation system two harvests a year would be possible in some areas. In other regions, where the rainfall is too sparse to grow anything successfully, conditions could be improved by irrigation. It is a fact that the rainfall varies greatly from one rainy season to the next. Even when enough rain falls and yields are good, the water supply is threatened. Farmers prefer raising crops to dairy cattle, for instance, because it is more remunerative. Where the grass is good, you still cannot keep more than one cow per hectare. The regions where it rains abundantly and regularly have been denuded of their forest in the course of time, and this tendency continues. The authorities are trying to put a stop to the felling of trees (which are used to make charcoal for cooking purposes), but in practice this is impossible to control. The deforestation goes on. And that jeopardizes the water supply and promotes erosion.

Erosion

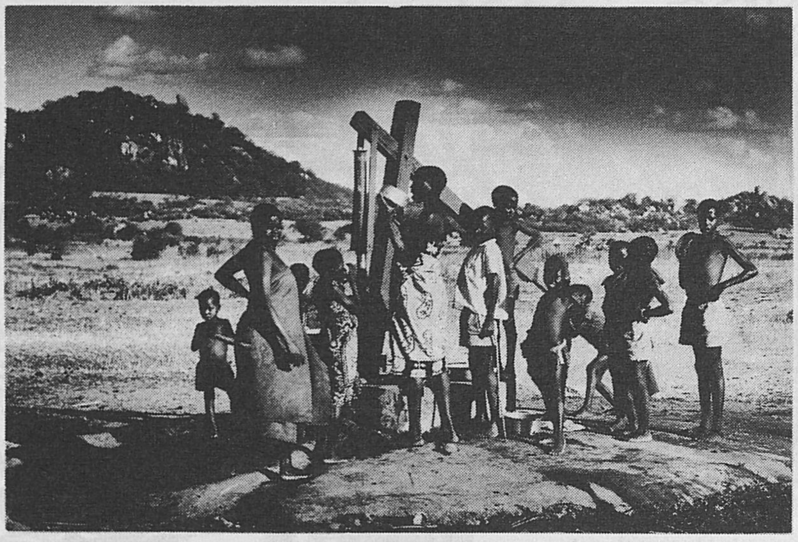
The efforts of the Tanzanian government to supply the rural areas with water will be fruitless, say the agricultural experts, unless they are coupled with an effective campaign to combat erosion. They consider soil erosion to constitute the biggest threat to the surface and ground waters of Tanzania. The gravity of this problem, which increases every year, is seriously underestimated. This may well be because it is almost impossible to tackle with the extremely limited financial resources available to Tanzania, one of the poorest countries in the world.



Dutch volunteer Rob van der Plas at the water purification plant.

TEXT 8 Dutch pumps project in Tanzania

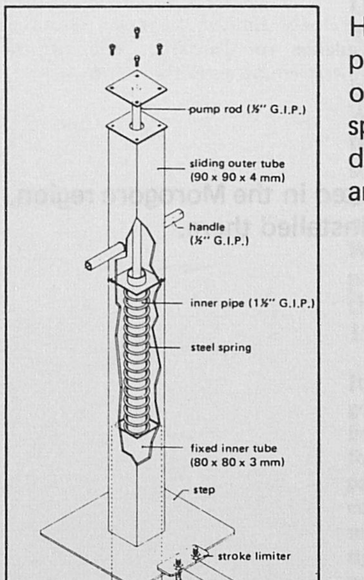
Between 1974 and 1978, 750 wells were dug in the Shinyanga region, operations being directed by a Dutch firm of consulting engineers. As most of the wells were shallow (up to 10 metres deep), the project was called Shallow Wells.
A special displacement pump called the Shinyanga pump was designed and built for the project.



The Shinyanga pump

However, the rotating parts of the pump were something of a problem and the pump broke down. A second pump, known as the kangaroo pump, was developed without rotating parts and that worked. When you step onto the pump a spring is depressed and the piston descends. When you step off, the spring is depressed and the piston descends. When you step off, the spring is released and the piston comes up again.

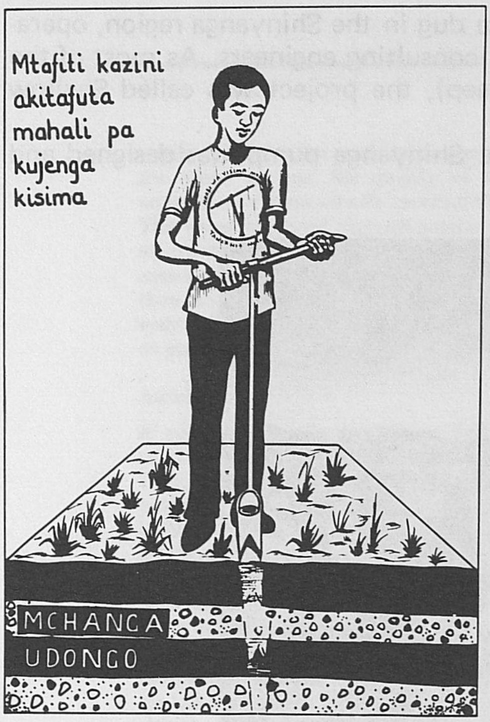
Diagram of the kangaroo pump



SHINYANGA * TANZANIA

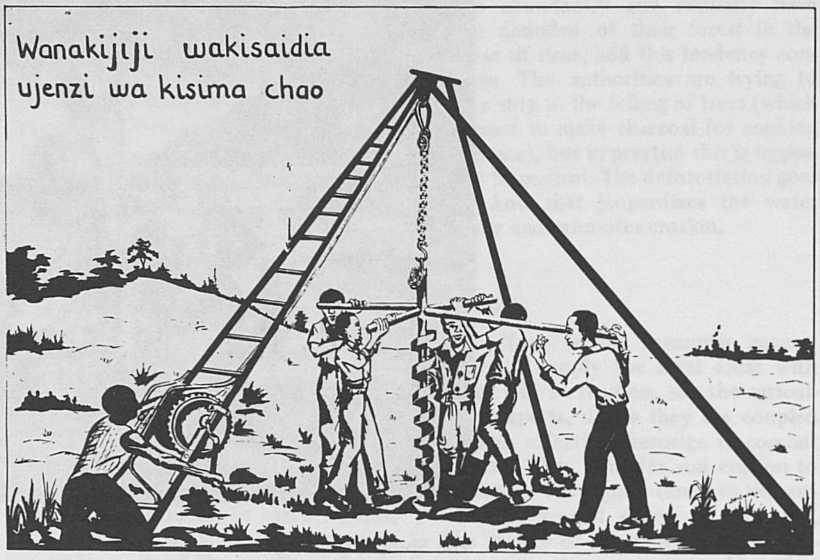
SHALLOW WELLS

Dutch pumps project in Tanzania

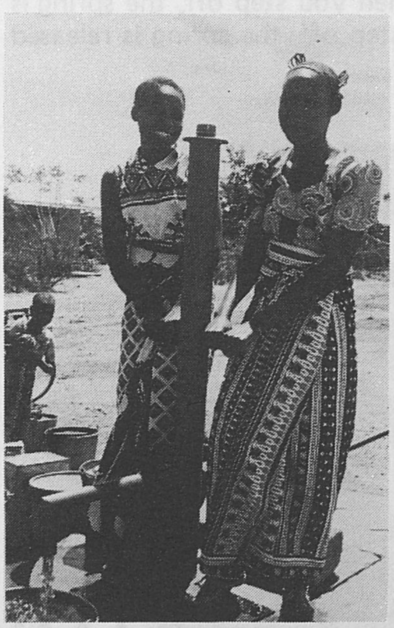


Illustrations
This man is looking for a suitable spot to make a well

More and more manpower was used in the course of the project and fewer machines. A hand drill was used whenever possible when prospecting for groundwater.



The villagers work together to build their well

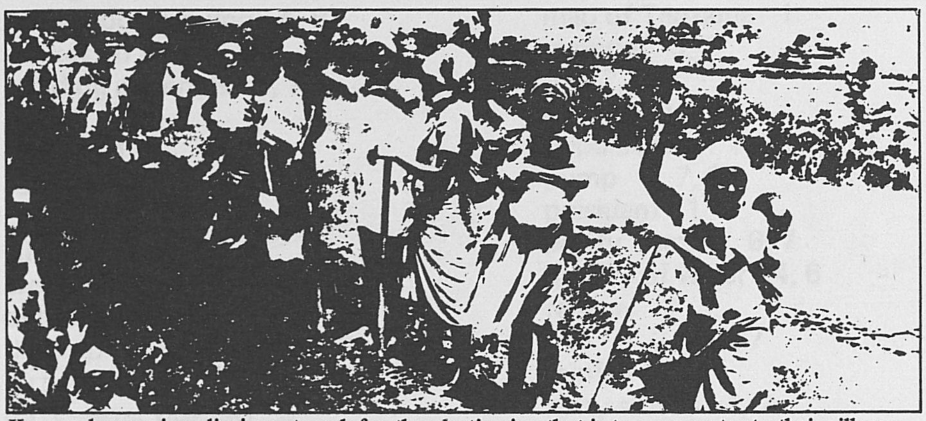


The kangaroo pump

In 1978 a similar project was started in the Morogoro region. Only kangaroo pumps are being installed there.

MOROGORO
MRADI WA VISIMA

Water Decade aims at having pure drink water for all by 1990



Kenyan housewives digging a trench for the plastic pipe that is to carry water to their village.

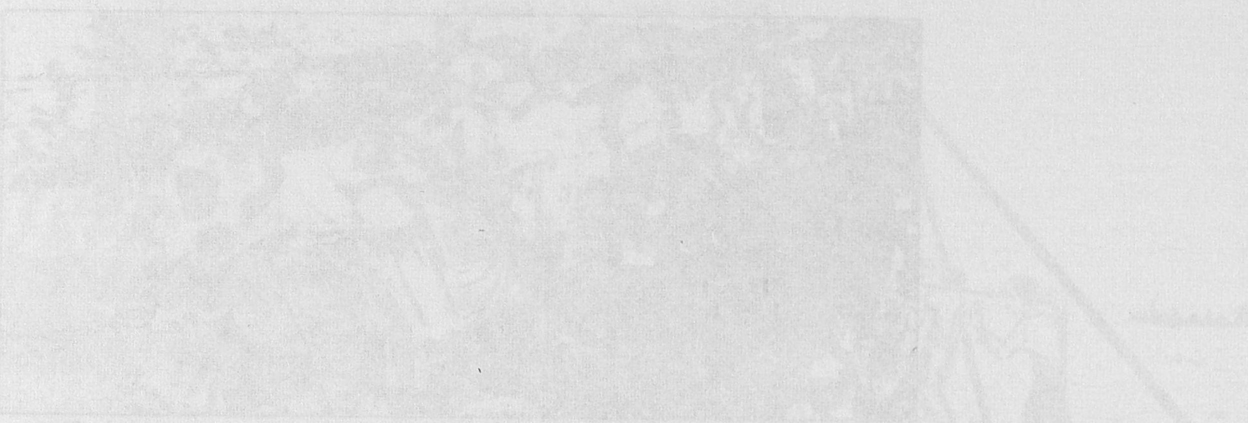
The Water Decade 1980-1990 was proclaimed at the headquarters of the United Nations in New York on 10 November 1980. All the UN specialised agencies such as the World Health Organisation, UNICEF, etc., and also all member states have been mobilised to co-operate in attaining the Water Decade's objective: pure drinking water for the world population by 1990.

It is an ambitious plan that is going to cost hundreds of millions, and the moment chosen for launching it is not very propitious. There is a general economic recession, which means that we all have to tighten our belts in the 'rich' countries as well as the Third World.
The 'rich' have in many cases stated that they will only be prepared to help if the developing countries put drinking water projects at the top of the list of their own development schemes. But it is not only a question of money. The people themselves must realise that the construction and maintenance of a public water supply requires effort and sacrifice on their part. They must be willing to do something about it themselves, like the Kenyan housewives in the photo above who are digging a trench for the plastic pipe that is to carry water to their village. This means they will no longer have to walk for hours every day to fetch water for their families. Having water on tap in the villages is going to revolutionize their lives, the way they spend their time and their household chores. That is one aspect of a water supply. But the most important is the improvement in public health which must inevitably result from pure drinking water. The United Nations has published some gruesome figures on this subject. 'Half of all the children in the world who die every year, die of diseases spread by water. Last year 13.6 million children died under the age of 5; 13.1 million of these deaths occurred in the developing countries and most of them were caused by diseases spread by water. 80% of all diseases in the world are related to water. 400 million people suffer from gastro-enteritis, 200 million from bilharzia and 30 million from river blindness'.

Half of all the hospital beds in the world are occupied by people suffering from diseases spread by water. And yet these figures are only a small part of the whole picture of death, suffering, restricted economic development and lost human potential caused by the lack of pure drinking water. Let us hope the Water Decade will change this.

Dutch pumps project in Tanzania

Water Decade aims at having pure drink water for all by 1990



... the plastic pipe that is to carry water to their village.

The Water Decade 1980-1990 was proclaimed at the headquarters of the United Nations in New York on 10 November 1980. All the UN specialised agencies such as the World Health Organisation, UNICEF, etc., and also all member states have [illegible] to [illegible] in attaining the Water Decade's objective: pure drinking water for the world population by 1990.

It is an ambitious plan that is going to cost [illegible] and [illegible] for [illegible] is not [illegible]. There [illegible] which means that [illegible] countries [illegible] World. The [illegible] have [illegible] stated that they will [illegible] prepared to help the developing countries put drinking water [illegible] the [illegible]

the [illegible]. But it is not only a question of money. The people themselves must realise that the construction and maintenance of a public water supply requires effort and sacrifice on their part. They must be willing to do something about it themselves, like the Kenyan [illegible] in the photo above who are digging a trench for the plastic pipe that is to carry water to their village. This means they will no longer have to walk for hours every day to fetch water for their families. [illegible] water in the village [illegible] time and [illegible] and [illegible] of [illegible] the most important [illegible] improvement in [illegible] health [illegible] from drinking water [illegible] United Nations [illegible] figures on the [illegible] of [illegible] the [illegible] spread by water. Last year 15 [illegible] million children died under the age of 5. [illegible] million of these deaths occurred

in the developing countries and most of them were caused by diseases spread by water. 80% of all diseases in the world are related to water. 400 million people suffer from gastro-enteritis, 200 million from bilharzia and 30 million from river blindness.

[illegible] of all the hospital beds in the [illegible] occupied by people suffering from [illegible] spread [illegible]

list of subjects

This is an alphabetical list of a number of subjects dealt with in the texts for reference and reading. The numbers refer to the numbered texts.

acknowledgement

Morogoro Wells Construction Project, Tanzania, *Fourth Progress Report*, July 1980, published by DHV Consulting Engineers i.c.w. ONV (Organisation of Netherlands Volunteers); Vincent Mentzel, Rotterdam; Unicef Photos by M. & E. Bernheim; Voorlichtingsdienst Ontwikkelingssamenwerking van het Ministerie van Buitenlandse Zaken; Development Cooperation Information Department — DHV Consulting Engineers, in *Shallow Wells*, second edition, P.O. Box 85, Amersfoort

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