A short comparative history of wells and toilets in South Africa and Finland

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Abstract: This paper describes the technological development of wells and toilets and the cultural practices related to them in two countries, South Africa and Finland, from the Middle Ages to modern times. Wells and toilets have always been linked to the well-being of humans and they still are the most common technical systems in the service of mankind. They are simple to build, but if they are constructed improperly or stop functioning properly, they may endanger the health of both humans and the environment. The solutions used for getting clean water or for disposal of excrement have always been a matter of life and death for human settlements. Located on opposite sides of the world, the climate and natural resources of South Africa and Finland are very different. However, surprisingly similar solutions, for example wind turbines to pump water, have been used in rural areas. Furthermore, urbanization and industrialization occurred in both countries at approximately the same time in the 19th century, which caused increasing environmental problems in Finnish and South African urban areas. The transition to modern water supply and waste disposal systems was a very demanding process for municipal administrations in both countries.

Key words: Urban environment, wells, toilets, environmental history, South Africa, Finland

Although South Africa and Finland, as a result of their respective geographic localities, appear to share little in common, there are, surprisingly enough, some interesting similarities. Both are countries with climatic extremes; South Africa with its aridity and heat; and Finland with its extreme arctic conditions. In a way, these extremes are comparable in terms of human sustenance. The most arid province in South Africa (the Northern Cape) and the northernmost province of Finland (Lapland) both cover 30 per cent of the surface area of their respective countries and both have an extremely low population density of 2 persons per square kilometre (*Table 1*). However, there

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are significant differences between the water resources of the two countries (*Table 2*).

Province	Population (million)	Area (km^2)	Density ($\#/km^2$)
Northern Cape	0.823	361830	2
Free State	2.707	129480	21
North-West	3.669	116320	32
Western Cape	4.524	129370	35
Eastern Cape	6.437	169580	38
Mpumalanga	3.123	79490	39
Limpopo	5.274	123910	43
Kwazulu-Natal	9.426	92100	102
Gauteng	8.837	17010	520
SOUTH AFRICA	44.820	1219090	37
Lapland	0.199	98946	2
Oulu	0.453	61572	7
Eastern Finland	0.604	60720	10
Western Finland	1.829	80975	23
Southern Finland	2.037	34378	59
FINLAND	5.122	336591	15

Table 1 Comparative population density for South African and Finnish provinces[1]

A comparison of rainfall indicates how much water resources diverge. Finland has a fairly uniform annual rainfall distribution (450 mm to 650 mm) whereas the annual rainfall in South Africa varies between less than 100 mm to more than 2000 mm. A large part of South Africa is considered to be arid (21 per cent has less than 200 mm annual rainfall) or semi-arid (44 per cent receives between 200 and 500 mm/year). Therefore some 65 per cent of the country does not receive enough rainfall for successful dryland farming. In Finland a much higher percentage of rainfall (55 per cent as opposed to 7 per cent) appears as surface runoff after evaporation and infiltration, consequently leaving Finland richly endowed with natural lakes and streams. There are approximately 56 000 lakes larger than 1 km^2 and the total number of all water bodies, such as rivers and lakes, is approximately 188 000 (Honkavirta 1998, 62; Myllyntaus 2004, 11-12; Pajula & Triipponen 2003, 9-10; Haarhoff & Tempelhoff 2004). In terms of renewable water resources, South Africa has only 45 per cent of the water of Finland, despite being four times larger. When factoring in the respective populations, Finland has 18 times more water available per capita than South Africa.

1 From www.statoids.com, accessed on May 1, 2005. Note that there are small differences in population numbers and land areas when compared to Table 1, which do not impact on the general trends demonstrated.

It is hardly surprising that South Africa is already exploiting a significant part of its total water resources. In the important Vaal River catchment area, which supplies the heartland of South Africa's manufacturing, mining and power industries, the critical limits of the natural run-off had been reached already in the 1980s and thus massive interbasin transfer schemes from other regions in South Africa, as well as from the neighbouring country of Lesotho, had to be implemented (Haarhoff & Tempelhoff 2004). While South Africa is already exploiting a massive 32 per cent of the theoretical maximum of its water resources, Finland uses only of 2.1 per cent of its theoretical maximum.

	SA	FINLAND	SA / FIN
POPULATION DENSITY			
[a] Surface area (km^2)	1 221 040	304 590	4.01
[a] Population (million)	43.309	5.172	8.37
[a] Population density (#/km^2)	35	17	2.09
WATER RESOURCES			
[h] Rainfall, including snow (mm)	475	575	0.83
[b] Runoff (mm)	35	318	0.10
[b] Percentage runoff	7%	55%	-
[a] Total water availability (km^3/a)	45	107	0.45
PER CAPITA WATER AVAILABILITY			
[h] Groundwater availability (m^3/a)	112	366	0.31
[b] Surface water availability (m^3/a)	1042	20902	0.05
[a] Total water availability (m^3/a)	1154	21268	0.05
PER CAPITA WATER USE	(2000)	(1995)	
[h] Groundwater use (m^3/a)	67	39	1.72
[b] Surface water use (m^3/a)	299	400	0.75
[c] Total water use (m^3/a)	366	439	0.83
RESOURCE EXPLOITATION	(2000)	(1995)	
[b] Groundwater exploitation	59.8%	10.7%	-
[b] Surface water exploitation	28.7%	1.9%	-
[b] Total water exploitation	31.7%	2.1%	-
WATER USE	[d] (2000)	[c] (1991)	
Percentage domestic use	[e] 14%	12%	-
Percentage industrial use	[f] 21%	85%	-
Percentage agricultural use	[g] 65%	3%	-

Table 2 Statistical comparison between South Africa and Finland.

a from Table 4.2 in *Water for People – Water for Life*[2]
b calculated
c from the EarthTrends environmental database[3]
d from Table 2.3 in *National Water Resourcde Strategy*[4]
e arbitrarily taken as 50% of urban/rural consumption
f taken as consumption for mining, power generation and 50% of urban/rural
g includes forestry
h from the Global Groundwater Information System[5]

In the context of this study, it is more instructive to view groundwater resources separately from surface water resources. In both countries, the renewal rate for groundwater is much lower than for surface water, but the relative exploitation of groundwater resources is higher. In South Africa, the exploitation rates for groundwater and surface water are 60 per cent and 29 per cent of the sustainable maximum respectively, while the same rates for Finland are 11 per cent and 2 per cent. In South Africa, about 20 per cent of *all* water is derived from groundwater. In Finland, about 60 per cent of the *potable* water supplied is derived from groundwater. Wells and boreholes form the backbone of rural water supply in both countries; there are about 600 000 wells in Finland serving single households or holiday homes (Salonen 2002) and more than 225 000 boreholes in the national South African groundwater database, which only reflects a part of the total. Two-thirds of South Africa's surface area is depends primarily on groundwater due to the lack of perennial streams. (http://www.dwaf.gov.za/Geohydrology/Databases/databases. htm) Groundwater is therefore of indisputable importance to both countries.

The efficiency of national water management practices is measured by the *Water Poverty Index* (WPI). The WPI incorporates the following aspects:

- Water resources available to the population
- Access of the population to water supply and sanitation
- Capacity (in terms on income and development) of the population to exploit the available water resources
- Efficiency of water use
- Environmental aspects such as water quality, pollution and biodiversity (Lawrence & Co. 2003).

The WPI evaluated 147 countries, and the relative position of South Africa and Finland in the different categories is shown in *Table 3*. Finland was ranked highest in WPI, while South Africa is in the bottom third of the countries included. A closer look at the WPI components, however,

2 Published by UNESCO (March 2003). Accessed on May 1, 2005 at http://www.unesco.org/water/wwap/wwdr/table_contents.shtml
3 Published by the World Resources Institute. Accessed on May 1, 2005 at http://earthtrends.wri.org/country_profiles/index.cfm?theme=2
4 Published by Department of Water Affairs (September 2004). Accessed on May 2, 2005 at http://www.dwaf.gov.za/Documents/Policies/NWRS/Sep2004/pdf/ Chapter2.pdf
5 Published by the International Groundwater Assessment Centre. Accessed at http://igrac.nitg.tno.nl/system.html

reveals that in terms of their natural water availability (which they really cannot do anything about) neither score that well, but their best ranking is in the environmental category, with South Africa at position 36 and Finland in position 1. All in all, the index reveals that the level of water management in Finland is excellent and fairly good in South Africa, given geographical and developmental constraints.

	South Africa	Finland
Resources	126	34
Access	86	6
Capacity	95	13
Use	72	57
Environment	36	1
Overall WPI	103	1

Table 3 The Water Poverty Index, as calculated for South Africa and Finland. All the values reported are the ranking of the 147 countries included in the survey, with 1 being the country with the highest score and 147 the country with the lowest score.

This article focuses in particular on two aspects of water management, wells and toilets, comparing the early experiences of both countries.

Wells in the countryside

The earliest sites where a safe supply of water was found were springs and freshwater streams such as small creeks. Not just humans, but also other mammals prefer flowing water and some even dig their own water holes – for example, elephants dig quite deep well-like holes in dry areas. On average an elephant needs to drink approximately 160 litres per day (ℓp/d); therefore the need for an adequate water source is obvious. The pit well, a simple deep water hole without any fortified walls, is the forerunner of the dug well. Water was taken from this sort of well by whatever means were available, usually just using simple vessels. One possibility was to form a chain of water carriers – this enabled the drawing of water from deep underground without advanced technology. In this way it was possible to reach water lying tens of metres deep, but then it was also necessary to get air down to those who were at the lowest level lifting the water. Water has been lifted from the dug well using the means available at the time, first with a bucket or a similar vessel, or possibly with the help of a rope or other tools. Different types of wells are described in *Table 4*.

Type of well	Techincal realization
I Natural spring & bottomless barrel in spring	no construction or very simple construction
II Pit well	pit in the ground, no construction or very simple construction
III Dug well	place and construction planned, built shaft, place carefully chosen by observing terrain
IV Tube well	pipe is pushed into the ground, place and construction planned, requires precise knowledge of ground water location
V Drill well	pipe is drilled on rock foundation, place and construction planned, requires precise knowledge of ground water location

Table 4 Wells by their technical realization (Categorization P. Juuti).

By approximately 3000 BC, the draw well with a counterpoise lift was invented in Babylonia and it was for over 2000 years the common and effective means to draw water. In Egypt it was called a *shaduf* and was used to lift water from rivers. Traditionally a draw well was built from wood, but some iron fortification might also have been used. However, the column, the counterpoise lift, the bucket pole and the bucket were wooden. If there was a need for a counterweight for the bucket, it was usually made of a heavier material. A windlass or winch was used when the well was very deep whereas the counterpoise lift was mainly used for shallower draw wells. They were followed by wind turbines, crank reels and hand pumps. The first tube wells in Finland were built at the end of the 19th century. Gradually the counterpoise lift and wind turbines were replaced by the electric pump or the drilled well. (Juuti & Wallenius 2005, 19) (See also *Table 5*)

Type of well	Method of lifting chronological order
I Natural spring & bottomless barrel in spring	Hand, scoop, bucket
II Pit well	Hand, scoop, bucket
III Dug well	couwell & rope, bucket pole, hand pump
VI Draw well counterpoise lift	counterweight
V Windlass well	whinch or reel
VI Tube & drill well	pressure of the groundwater formation or pump
VII Wells with wind engine	wind power, rotor
VIII Wells operated with engine	combustion engine, electricity

Table 5 Wells by method of lifting water (Categorization P. Juuti).

In the countryside, watering livestock formed the major part of the water consumption. Thus, if possible, the well was placed closer to the cowshed than the house itself – humans need only a few litres of water to drink per day. According to estimates made by the Finnish Committee for household efficiency, the distance between the cowshed and the well was nevertheless approximately 50m in the 1930s. Likewise the sauna (the Finnish washing place), was often placed close to the well to ease the burden of carrying water. A study by the Finnish Ministry of Agriculture shows that wells were the most common source of water in the countryside in the early 1950s and that only seven per cent of the households were connected to a water supply pipe. The most commonly used methods to draw water were a bucket, a hand pump and a winch (Katko 1988, 8–11; Paulaharju 1958, 32–33; Paulaharju 1906, 7).

The early indigenous nomads of South Africa had no need to construct elaborate water supply systems. When the very dry areas of the Northern Cape Province had good rains and vegetation the nomads moved in, and left when the drier seasons arrived. From the eighteenth century, white colonist farmers copied this practice, with a large-scale "trek" every year with their cattle and sheep to follow the available water and vegetation. Water was taken from surface depressions and streams immediately following the rains and from shallow dug wells in river-beds for the weeks following. As communities settled, the need for permanent water supplies became essential. For the very dry regions, however, the digging of a permanent well represented a large investment in time and effort, which would require land tenure and secure ownership. Where farmers could get their title to the farmland, the water supply systems were developed from the eighteenth century. In some of the very dry regions, the land stayed under government control as the so-called "crown lands" and here the water supplies were not developed until as late as the early twentieth century, when the farms were eventually sold to individual owners (Van der Merwe, 1945a, 209).

The digging of wells required much effort to get through the hard banks of stone and rock. Besides shovels, picks and chisels, heating the rock with fire and quenching with water was an early method of getting through (Van der Waal-Braaksma & Ferreira, 1986, 63). Later, some fairly ineffective home-made explosives were tried, but things only got better in the 1880s when the newly established South African mining industry, as a side effect, made it possible to procure dynamite. Digging the wells was slow, typically requiring about three months for well with a depth of 45m – equivalent to 0.5m p/d. Getting water and other supplies from far away to the well-diggers during the many months when the wells were being dug, presented a major logistical problem. Moreover, only 20-25 per cent of the attempted wells struck water and the others had to be aborted (Van der Merwe, 1945b, 44).

Illustration 1. A typical shallow pit well in South Africa, showing the platform from which the water was drawn.

Where the water was close to the surface, a typical well was a dug well, 2-3m deep and about 5-6m in diameter, encircled by a low wall to keep the animals from the water. Inside the well, a flat stone just above the water level would serve as a small platform from where a person would scoop the water with a bucket and empty it directly into a small channel leading to a drinking-trough outside the wall, where the animals would drink (see *Illustrations 1 and 2*). When the well was deeper, up to about 5-10m, a lever was used, similar to the ancient Babylonian design, or a series of steps would be carved to allow the "human chain" to lift the water by progressively passing on the bucket. Deeper than this, the buckets had to be winched out with a primitive reel (see *Illustration 3*).

An interesting variation on this method was to use two to four donkeys on the surface to hoist the bucket by pulling the rope over the reel. By leading the donkeys away from the well, the bucket would be lifted. After the bucket had been emptied and dropped back into the well, the donkeys were brought closer to the well and the cycle was repeated. This use of animal-power allowed the use of much larger buckets of between 45 and 90ℓ (Van der Merwe, 1945a, 257).

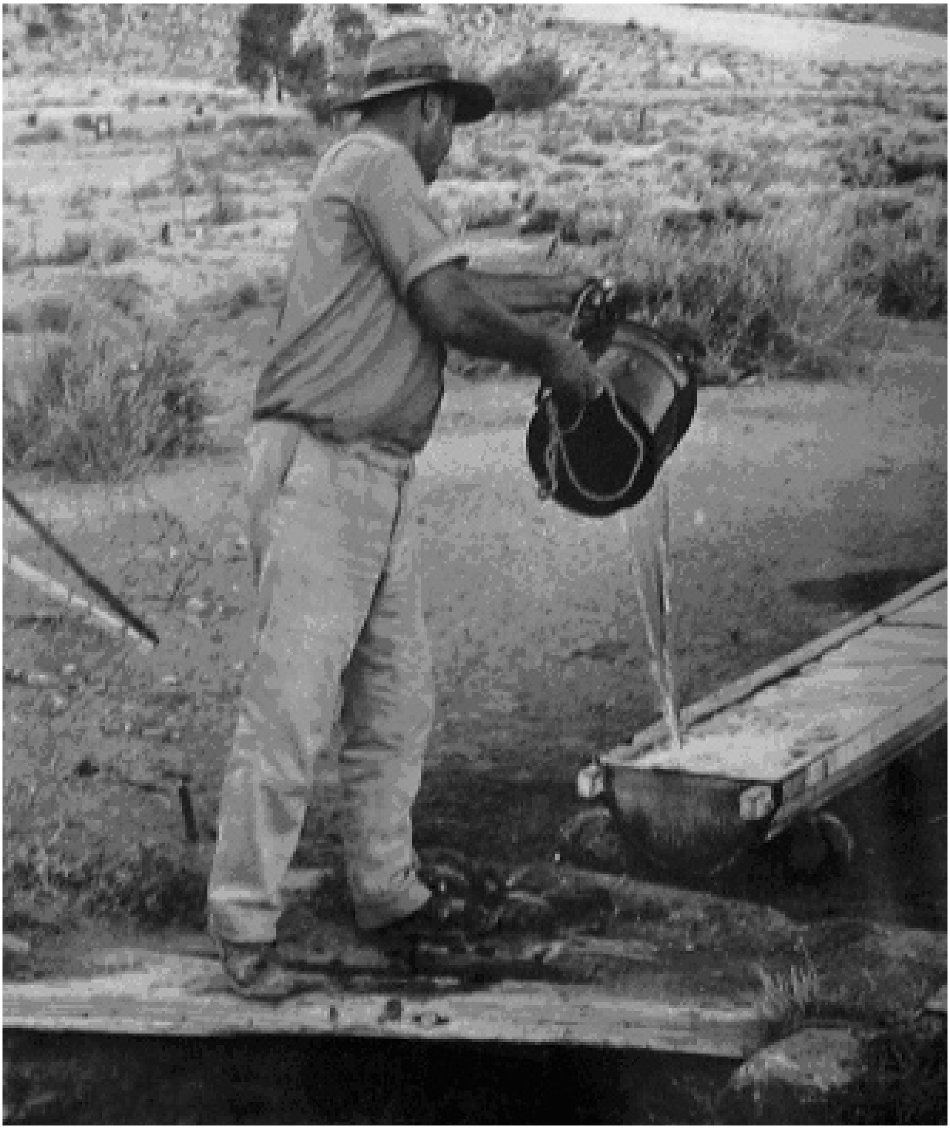

Illustration 2. Water being hand drawn from a shallow pit well in South Africa, and transferred to a livestock watering trough.

Typical of South African wells in the remote rural areas, was the reliance on hand-made equipment using local materials. Home-made explosives were packed in a bottle, provided with a fuse and sealed with beeswax. Buckets were made of canvas and water-proofed with animal fat. A circular ring was fixed to the top of the bag to keep the bucket 'open', with a second ring sometimes at the bottom. To simplify the emptying of the large buckets when the donkeys were used, a canvas spout was fixed to the bottom of the bucket, long enough to be tied to the handle of the bucket while it was being filled and lifted – a very simple valve! Buckets were sometime made of more durable leather and stored in the cool, moist area immediately above the water in the well to extend their lives, but only lasted eight months at the most (Van der Merwe, 1945a, 258).

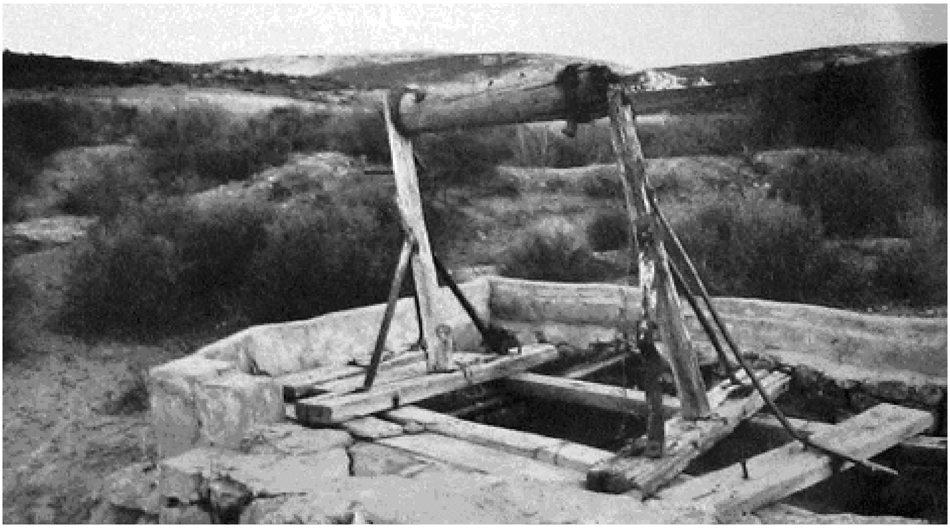

Illustration 3. A deeper well (in South Africa) with a reel, dating back to 1880.

When a well with good water was found, special measures had to be taken to ensure that different herds of sheep could be adequately watered without getting mixed up. A simple method to extend the watering capacity was to have two or more watering-troughs extending from the same well, to allow more than one herd at the well at a time. A more elaborate arrangement was to dig more than one well close to each other, thus increasing the water production rate. The importance of such watering-points are reflected in the indigenous languages of South Africa – a strong water source was known as 'the womb' and an area which allowed more than one well at the same point was known as a 'stomach' (Van der Merwe, 1945b, 105, 259).

In South Africa wells with wind turbines replaced all the other types of wells outside of urban areas at the beginning of the 1870s. The first wind turbines were imported from England, America and Australia (Walton, 1954, 155). The drawn-out war between the Boer Republics and Britain, known as the Anglo Boer War (1899 and 1902) brought agricultural development to a practical standstill. In 1903, soon after the war and in the time of rebuilding the country's agricultural production capacity, a devastating drought struck South Africa. This accelerated the introduction of the wind turbine and accounted for the fact that wind turbines were recorded for the first time in 1904 by the Cape census, which reported that in the Cape Colony there were 1275 wind turbines and 364 water wheels in use. By 1914 there was, for example, one wind turbine for every 4000 ha in the Reddersburg district in the Free State Province. In the drier parts such as Bushmanland in the Northern Province, the development was slower and by 1945 a farmer with one wind turbine for every 5000 ha was considered to be fortunate. According to the South African agricultural census in 1926, the number of wind turbines on the country's farms was 44 000, in 1946 101 000 and in 1955 151 000. In 1942 the first wind turbines were locally manufactured and the Climax company alone (there were others as well) had manufactured 150000 units by 1974. (Archer, 2000, 682; Walton, 1954, 155; Van der Merwe, 1945b, 51). In recent times, technology has evolved further and the use of submersible pumps in boreholes and solar power spread into the Karoo (a dry area in central South Africa) during the 1980s and 1990s.

A wind turbine (*Illustrations 4a and 4b*) is very reliable and usually requires very little maintenance. Wind power is still used on a large scale in South Africa. In 2003 there were about 300 000 wind turbines on farms across South Africa, second in number only to Australia. Nowadays even in the most desolate wastelands of the Karoo, it is hard to find a place where a wind turbine cannot be seen. These turbines make many of the most arid parts of South Africa habitable. They are primarily used for watering livestock and supplying communities with water. (http://www.africaguide.com/facts.htm, 12.5.2005; South Africa Yearbook 2003/2004, 481).

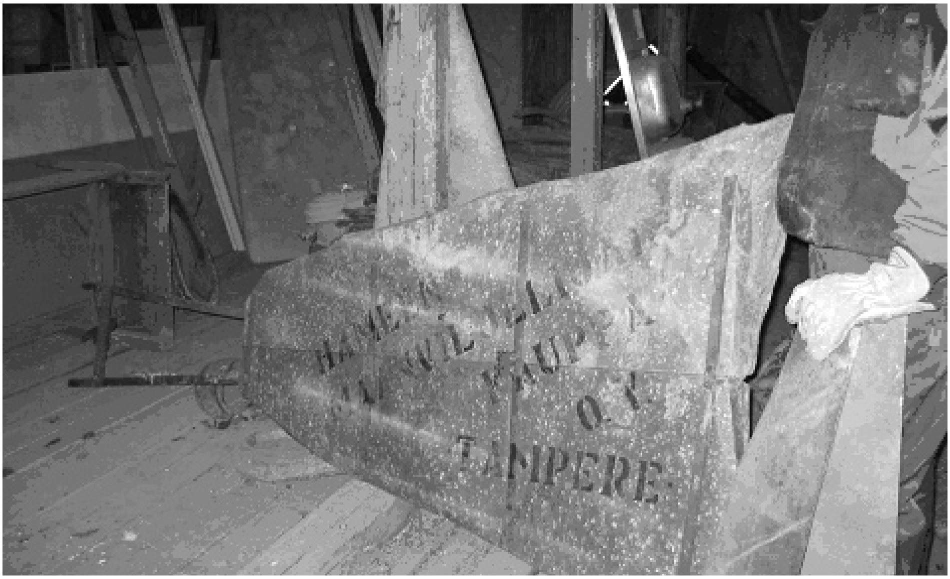

Illustration 4a Wing of wind turbine (length more than 1m), at Lihasula Estate, near Tampere.

Illustration 4b A typical wind turbine in the Northwestern Cape, South Africa, on the farm Nanibees, Brandvlei District. The wind turbine, also known as a windpump in South Africa, was manufactured in the industrial city of Vereeniging in the mid-twentieth. After having fallen into disuse it was recently restored, with good effect by the owner of the farm, Mr. Francis Visagie. (Photograph: Magda Morrison (2003) with additional information by Theo Venter), Editor.

First urban wells and toilets

Compared to the rural areas with scattered settlements, castles and cities were more densely populated – the same space was sometimes shared even with a large number of livestock. Securing the water supply was of utmost importance when the layout of a castle or fortress was planned. A location near water provided a good means of transportation and on the other hand also protection against enemies. It was necessary to get water from the surroundings or preferably even inside the walls, otherwise the general safety would have been endangered significantly under siege conditions. To have a well was important also in case of fire, for it was a constant threat even in times of peace (Juuti & Wallenius 2005, 69; about sieges: see Syvänne 2004, 295-303).

The first toilets did not require much technical construction; they were just holes in the ground. In the world today, sadly, the most common type in use is still the most primitive – a hole dug in the ground. An evolved, Finnish version of this latrine hole is *riuku* – with supporting, vertical logs on both sides of the hole and horizontal log(s) attached to them. It's been used widely by the Finnish army, especially during World War II, and the *riuku* was also introduced to later generations of young Finns doing their military service (Juuti & Wallenius 2005, 29; Katko 1996, 96). *Riuku* was designed so that even several people could sit on it. A popular story from wartime Finland tells how the Soviet Red Army troops were sometimes beaten just because of the lack of good sanitation. Finns always had their *riuku* further away from their camps and sources of water. The Red Army was not as careful and at times the fighting condition of the troops was quite poor. There is a grain of truth in this story, for during military campaigns diseases spread among the troops with devastating results. A good example of successful maintenance is the army of the Roman Empire, which took good care to provide vital water supply and sanitation (Syvänne 2004, 104).

Upgrading doesn't always mean improving, for the most dangerous type of toilet is the "modern" water closet, which is *connected to a sewer without wastewater treatment facilities*. This kind of system had caused fatal epidemics and the pollution of small lakes on many occasions. An Englishman, Joseph Bramah, is usually named as the developer of the first actual water closet, in the year 1786 (Juuti 2001, 38; Wijmer 1992, 60-62).

The compost toilet is the most environmentally friendly, especially the dry compost model in which urine is collected separately. Urine diluted with water can be used as fertiliser and composted solid waste can be used for soil improvement. The amount of urine produced by one individual in a year could be used to produce 200kg of grain. This method not only recycles the nutrients in the urine but it also prevents them from getting into the groundwater and watercourses. Other advantages worth mentioning are that the whole process is quite easily managed by the users themselves and the separation of urine and faeces also reduces the offensive smell. The compost toilet can thus offer a possible solution to the problem of famine often coupled with poor hygiene. It's notable that in the nineteenth century there were already dry compost and compost toilets in cities joined with different transportation systems. Choosing the water closet for the primary system in the late nineteenth and early twentieth century effectively stalled the product development of dry compost and compost toilets for over a hundred years (Mattila 2005, 41; Juuti & Wallenius 2005, 29). (See *Table 6*)

Toilet	Method	Consequences / Results
i Pit	none or covered with soil	waste won't compost
ii Outhouse & WC, no waste treatment	none	leakage in ground or into body of water, environmental hazard, wells and watercourses endangered
iii Transportation of waste within organization	centralized collection of waste	depends on further treatment
iv WC, flush water led into watercourse	waste flushed and led into watercourse	catasrophal, watercourse and in wost case drinking water contaminated and polluted
v WC with precipitation tank	heavier matter sinks to the bottom of the precipitation tank (one or multiplepiece)	refinement only partial
vi WC with closed wastewater tank	waste flushed into tank, then collected and transported to the network of sewer works	good
vii WC with filtering on the ground	often with the precipitation tank	result varies
viii WC and treatment plant	small local waste treatment plant	result varies
ix WC, connected to the sewer network	wastewater treatment plant	advantages of bigger units: better treatment result
x Compost toilet	composting	controlled recycling of units

Table 6 Toilets – method and consequences of treating the waste. (Categorization P. Juuti).

The oldest remaining wells and toilets are usually found in castles – both in Finland and South Africa. The castle of Good Hope in Cape Town in South Africa provided shelter and protection to soldiers and administrative staff, but it also provided good water from its wells. Cape Town was established by the Dutch in the seventeenth century and is the oldest European-style city in South Africa. It is situated by the sea and is the centre of the second largest metropolitan complex in South Africa. In the castle there is one big dug well, the so-called Kat well and a couple of smaller ones. The Kat well is, according to Werz, the oldest still remaining well in South Africa and dates back to the year 1682 (Werz 2002, 97). The Kat well had a reel and its walls were made of stone, which was a quite typical method of construction. Building this type of well requires quite good planning, expert builders and resources such as money or manpower (Juuti & Wallenius 2005, 12-15). Originally the Kat well was built in the centre of the castle and it was about 10m deep and 2m in diameter. In 1691, a long building was constructed across the castle courtyard and the well was left inside, but it was still accessible to the inhabitants (Werz 2002, 95-96). Later, in the early 1700s, the Kat well