"Making Water"

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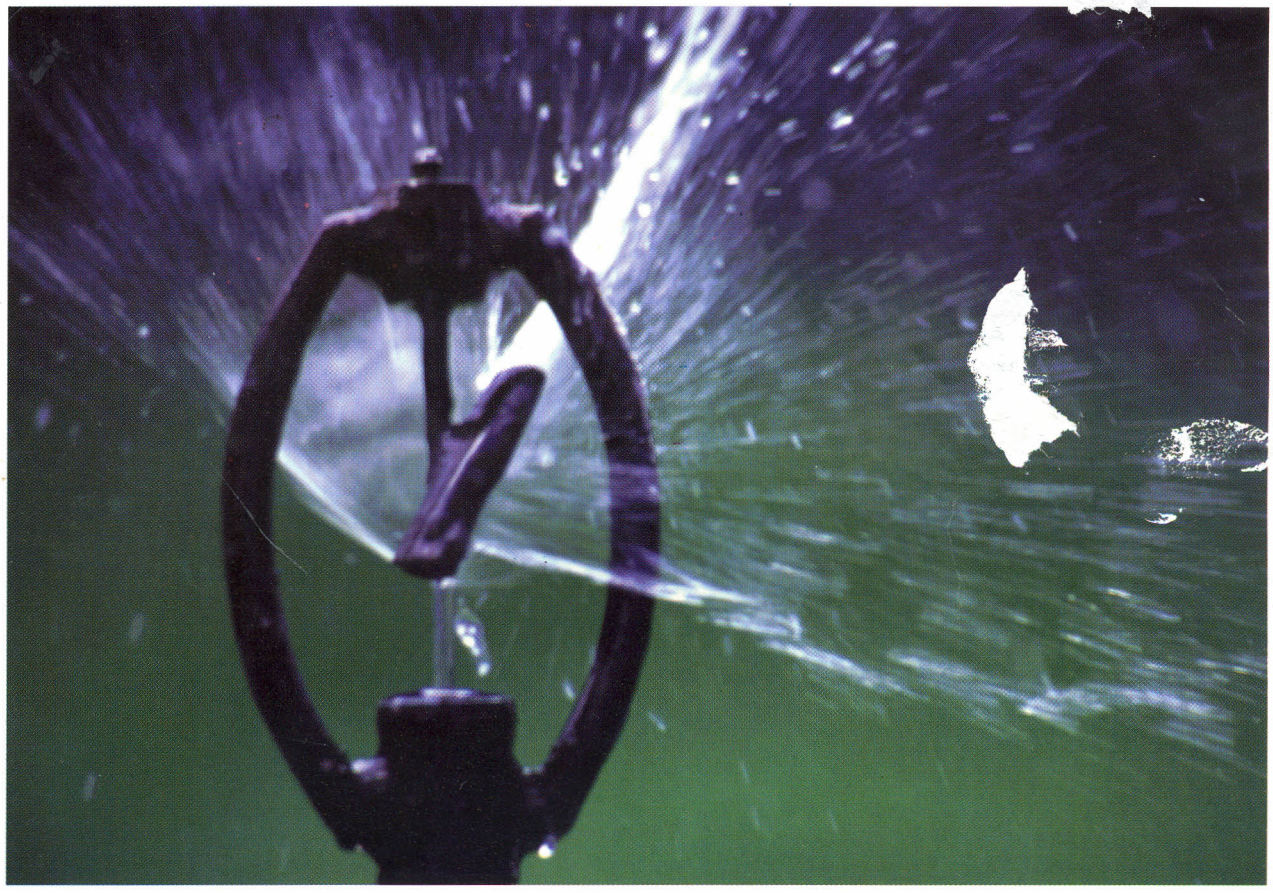
Making Water

An Appraisal Of "Jua Kali" Sprinklers In Kenya



BACKGROUND

In the past 10 years the strategy of the Kenya Government has shifted from expansion of large-scale irrigation schemes to the development of smallholder irrigation systems. Since 1992, the Government has adopted a cost-sharing policy for the implementation of irrigation projects. Farmers are expected to pay the full costs of infrastructure, as well as operation and maintenance, through a system of commercial loans. The privatisation of some irrigation services and the financial autonomy of public agencies are also being promoted. The implications of these policies are that development of irrigation is likely to be concentrated in higher potential areas, and that farmers' involvement in all phases of project development will be greatly enhanced. This, in turn, should favour technologies which are low cost and easy to operate and maintain. It is therefore expected that the private sector will play an essential role in the provision of services and in the creation of technologies.

In 1991 Terra Nuova, an Italian NGO, carried out a study in collaboration with the University of Nairobi and the Ministry of Agriculture, on sprinklers manufactured by local artisans in the Mt. Kenya area. The objectives of the study were to assess the performance of these "Jua Kali"[1] sprinklers, the scope for improvement and the level of diffusion among smallholder farmers, with a view to identifying ways to promote wider adoption of this type of sprinkler in gravity-fed, low pressure irrigation systems. In 1994, Terra Nuova carried out an informal survey in the same area, this time focusing on the manufacture of the sprinklers.

This document is a synthesis of both surveys and attempts to elucidate, with text and illustrations, the creativity of local artisans in the circumstances in which they operate.

The Context

PHOTOS 1 & 2: SMALL PLOTS, HIGHLY DIVERSIFIED

Smallholder irrigation in the area surrounding Mt. Kenya is characterised by a great diversity of farming systems, due to climatic conditions, land size and proximity to roads or urban areas. Access to water for irrigation is possible when a farm is situated near one of the permanent streams which descend from Mt. Kenya.

Although irrigation is useful in spreading labour peaks, and in securing food and cash crops against the risk of rain failure, in this area it is mainly used to produce horticultural crops in high demand periods for the domestic and export markets (Photo 3).

Despite their perishability and market uncertainties, horticultural crops have been shown to give higher returns than any other crop. Their continuous harvesting provides regular income and allows for labour demand fluctuations, while their relatively short growing cycles provide rapid returns to the production factors employed, and an opportunity to adapt rapidly to climactic and market variations.

PHOTO 3: HARVEST OF SNOW PEAS FOR THE EXPORT MARKET

The Context

There is no doubt that irrigation is now gaining momentum in the Mt. Kenya region, mainly due to the profitability of vegetable production. Farmers are able and willing to invest in infrastructure which guarantees a regular and reliable water supply. This is crucial as most horticultural crops are very sensitive to water shortages.

The spread of horticultural production in this area has had two major effects on the development of irrigation:-

- the increasing demand for water resources has accelerated the use of water-saving technologies;
- the high returns to land and labour offered by horticulture production are incentives for farmers to invest in more capital-intensive technologies.

In this context, there has been a rapid expansion of overhead (sprinkler) irrigation systems which are less labour-intensive, less water-demanding and more adapted to hilly topography than surface application systems.

Most irrigation systems are communal with as many as 500 farmers sharing the same source. Individual farmers using diesel pumps to lift surface water are growing in number. Water is generally drawn from rivers through a temporary or permanent diversion weir, and then conveyed through the farming area in an open channel or by a closed pipe system (Photo 4). Profitability of horticultural production has also stimulated farmers to use their domestic water supply systems to irrigate small portions of land near the homestead. In all these systems, water is conveyed through the field by connecting a flexible hose-pipe to the water outlet and by fixing to it one or more metal risers, each supporting a sprinkler (Photo 5).

PHOTO 4: A TYPICAL IN-FIELD SYSTEM

PHOTO 5: THE FLEXIBLE HOSE-PIPE

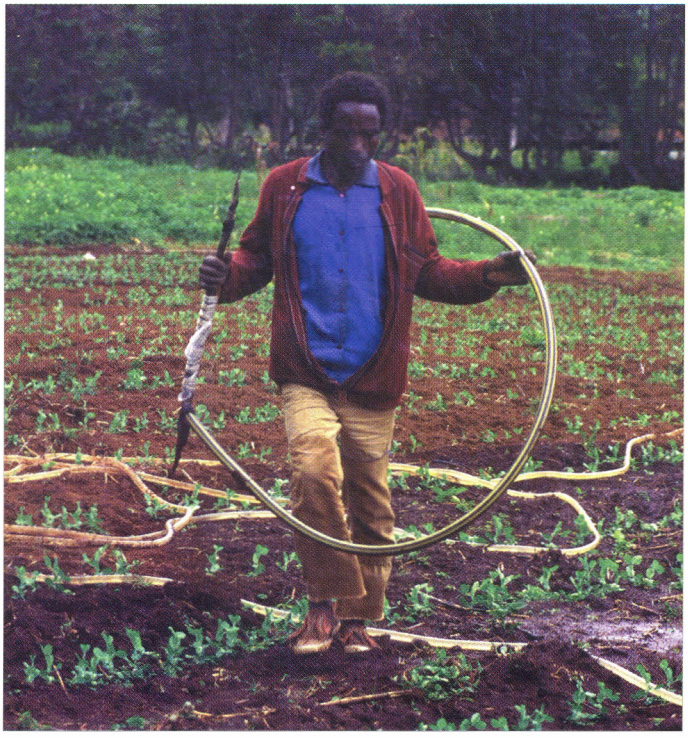


PHOTO 6: SPRINKLERS ARE MOVED FREELY IN THE FIELD.

Irrigation systems generally function on-demand - a valuable condition for successful horticultural production; however, because many farmers share the same water source, each user has little control of the flow and pressure at farm level. This implies that farmers must cope with the uncertainty of a variable and therefore unpredictable water supply. Farmers' responses to these conditions include:-

- varying the duration of irrigation and the interval between successive irrigations;
- varying the number of sprinklers in use;
- using different types of sprinklers;
- using flexible hose-pipes and moving them freely in the fields according to their perception of water requirements (Photo 6).

Having access to different types of sprinklers is essential to the farmers' strategies. During field surveys carried out between 1991 and 1994 in the Mt. Kenya area, a great variety of sprinklers were found and an attempt was made to define a typology. Types were classified according to their mode of operation and, within types, models were differentiated by the materials and technology used.

Types of Sprinklers

IMPACT SPRINKLERS

In this type, the sprinkler head is rotated by a small hammer which is activated by the force of water striking against a vane connected to it. Impact sprinklers are characterised by their long range distribution and by low application rates. This makes it possible to leave them on the same spot for longer periods than other types. Farmers prefer to use impact sprinklers on tall standing crops (maize, coffee) or on horticultural crops at a mature stage because the large droplets tend to damage young crops and compact the soil (Photo 7).

Most of the impact sprinklers found in the field were imported models, but an artisan from Embu does manufacture this type, though only on order (Photo 8).

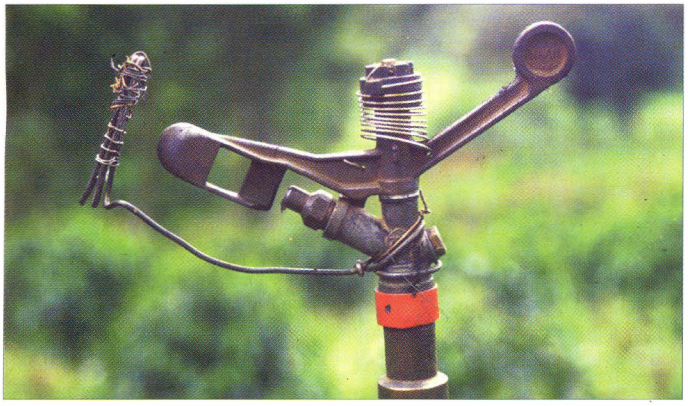


PHOTO 7: AN IMPORTED IMPACT SPRINKLER "MODIFIED" TO BREAK THE JET INTO FINER DROPLETS.

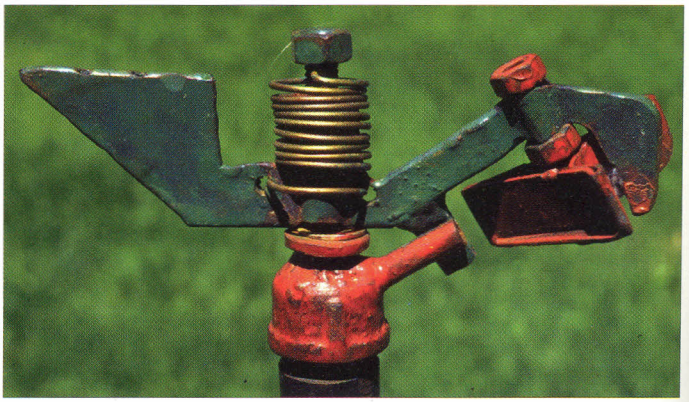


PHOTO 8: JUA KALI IMPACT SPRINKLER (KAMAU, EMBU).

BUTTERFLY SPRINKLERS

Rotation above the nozzle through pressure of the vertical jet enables the butterfly to spread water in all directions. Different models were identified according to whether the frame of the sprinkler was fixed or whether it rotated around a vertical axis passing through the spindle; models were also categorised according to the materials used in their manufacture (Photos 9, 10 & 44).

Farmers use this type in all conditions, including watering their vegetable nurseries. With low pressures, the butterfly of some models tends to rotate slowly and to produce a very small wet area. With very high pressures, water droplets tend to break into a fine mist which is easily carried away by the wind. Butterfly sprinklers were by far the most common type found in the area.

PHOTO 9: BUTTERFLY METAL MODEL WITH FIXED FRAME (KAMAU, EMBU).

PHOTO 10: BUTTERFLY METAL MODEL WITH ROTATING FRAME (KAMAU, EMBU).

REACTION SPRINKLERS

Reaction sprinklers rotate through a torque produced by water channelled into two opposed PVC pipes. Three artisans were found producing this model, each with slight variations (Photos 11, 12, 13 & 14).

Reaction sprinklers, at low and high pressures, were found to have the best uniformity of wetting pattern when tried in controlled conditions. The model found in Embu District (Arkangelous Nderi) in 1994 was reported to work at pressures produced by a hand pump (Photo 14).

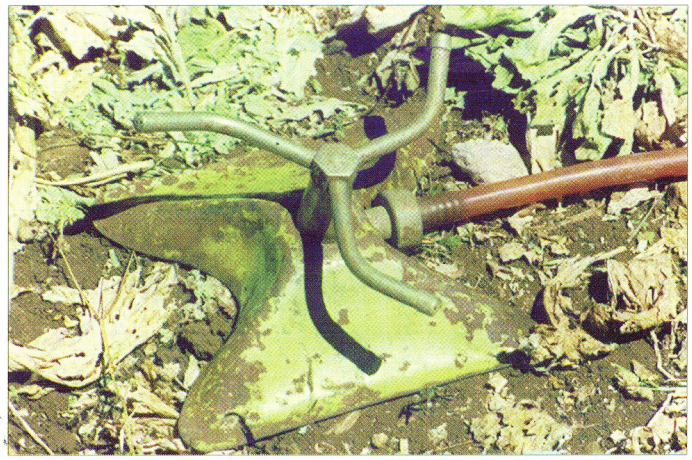


PHOTO 11: IMPORTED REACTION SPRINKLER.

PHOTO 12: JUA KALI REACTION SPRINKLER (UNKNOWN ARTISAN, KANGEITA)

PHOTO 13: JUA REACTION SPRINKLER (KAMAU, EMBU).

PHOTO 14: JUA REACTION SPRINKLER ("ALI", EMBU).

STATIC SPRINKLERS

PHOTO 15: JUA KALI STATIC SPRINKLER, "BOLT" MODEL, (AARON M'TURUCHIU, MERU)

PHOTO 16: IMPORTED STATIC SPRINKLER.

These sprinklers distribute water in all directions at the same time, and therefore produce fine droplets which tend to be carried away by the wind. In consequence, they are characterised by short ranges, high intensities of rain and low uniformity.

A few models have been identified which were mainly used to water vegetable nurseries (Photos 16, 17 & 18).

PHOTO 17: JUA KALI STATIC SPRINKLER (SOSPETER KABUA, NAIROBI)

Criteria for Choice of Sprinklers

Farmers therefore have a wide choice of sprinklers, both imported and locally manufactured. They decide which sprinklers to purchase according to four main criteria.

PRICE:

Large variations in price were found according to the materials and technology used, the time required to manufacture one piece, the place of sale, the inclusion of the stand, and some sort of guarantee in the price. In November 1994, prices ranged between 70Ksh[2] for one model of PVC reaction sprinkler, and 350Ksh for a butterfly "pedal axle" model (Photos 18 & 19) or an impact type. No price was recorded for butterfly plastic models made with recycled materials, but it is likely that, as the 1992 survey showed, these would have been the lowest in price.

AVAILABILITY:

This refers not only to the manufactured implement, but also to the availability of spare parts and repair facilities. Farmers' choice of an implement is partly based on the possibility for local repair at a cheap price (Photo 20).

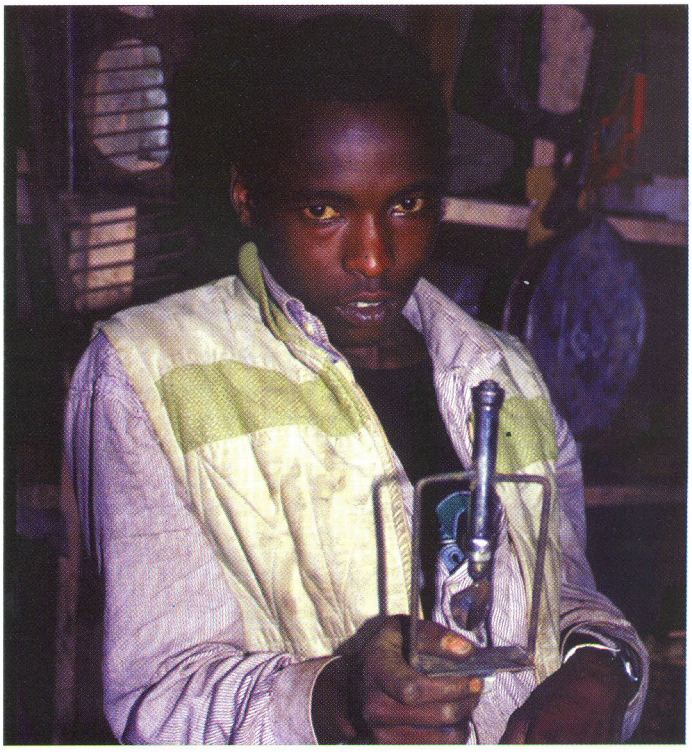


PHOTO 18: JUA KALI BUTTERFLY "PEDAL AXLE" MODEL (JOSEPH GITUMA KWIRIGA, MERU)

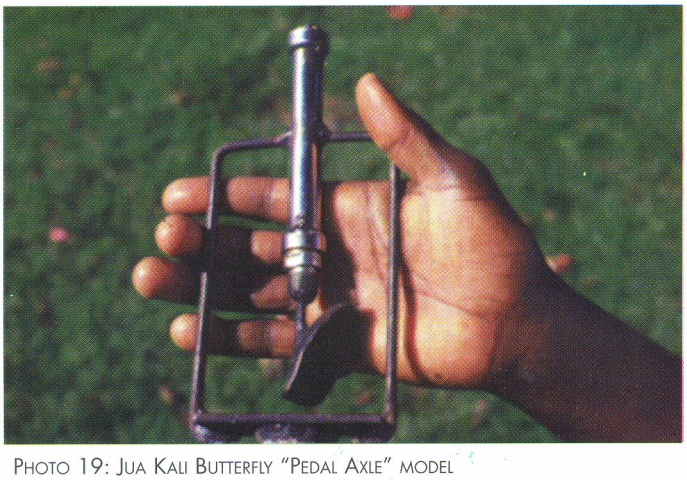


PHOTO 19: JUA KALI BUTTERFLY "PEDAL AXLE" MODEL

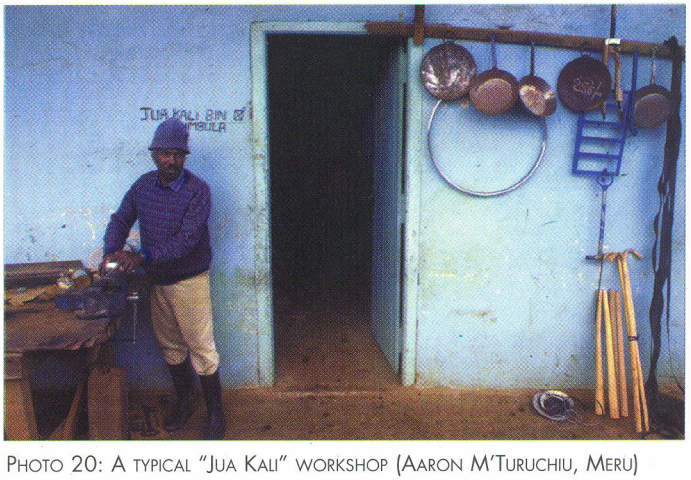


PHOTO 20: A TYPICAL "JUA KALI" WORKSHOP (AARON M'TURUCHIU, MERU)

DURABILITY:

Farmers and artisans frequently refer to the durability of different models, when operated in approximately the same conditions. However, it is impossible to establish "objectively" a ranking of sprinklers based on durability because of differences in materials and technology used in construction. Furthermore, even if "similar" models were compared, it would be impossible to determine from farmers' interviews which is more durable because the water pressure, the intensity of use and the level of maintenance vary from farm to farm. Durability can also be perceived differently, according to which part wears out faster and how easy it is to repair or substitute the part.

PERFORMANCE:

Conventional measures of performance for sprinklers are the "coefficient of uniformity" and the distance of throw. Performance is usually estimated for a range of pressures.

Since "Jua Kali" sprinklers are not accompanied by specifications, and since farmers seldom have the opportunity to test them beforehand, performance as intended is not a criterion for purchase. However, farmers have their own criteria to judge the performance of each type of sprinkler, and will select according to the operating conditions (i.e. pressures and flows) prevalent on their farms and the crops they expect to irrigate. As shown below, farmers try to purchase several different models that they can use when conditions change.

Criteria for Performance Assessment

The main factors which farmers consider in assessing sprinklers performance in the field are:

CROP & SOIL DAMAGE:

This is an indicator of water droplet size which is normally affected by a combination of the following factors:

- Operating pressure: all other conditions being equal, the higher the pressure, the smaller the droplets.
- Method used to break the jet: impact sprinklers do concentrate the jet and therefore tend to produce bigger droplets, not suited to young crops and bare soil (Photos 21, 22 & 23). At the opposite, static sprinklers produce a fine mist which is better suited to irrigation of vegetable nurseries.
- Size of the nozzle: the larger the nozzle size, the bigger the size of droplets.
- Speed at which some of the sprinklers rotate: for instance, in butterfly sprinklers speed of rotation of the butterfly, as well as being influenced by the pressure available in relation to the nozzle size, is also affected by the distance between nozzle and butterfly, shape and material of the butterfly, smoothness of rotation of the spindle (the latter partly affected by the degree of wear and tear).

PHOTO 21: IMPACT SPRINKLERS TEND TO PRODUCE BIGGER DROPLETS

PHOTO 22: IMPACT SPRINKLERS ARE USED ON MATURE CROPS.

PHOTO 23: BUTTERFLY SPRINKLERS ARE PREFERRED FOR SEEDLINGS

PHOTO 24: SHORT RANGES IMPLY A SMALL WETTED AREA

In addition to its effect on crops and soil, size of droplets also influences evaporation and drift losses (the smaller the drop size, the higher the potential for loss), and the application rate.

DURATION OF APPLICATION:

This is an indicator of the application rate. Farmers reported that they move the location of the butterfly sprinklers after a period of between 0.5 - 2 hours. However, when they use impact sprinklers they can leave them on the same spot for between 3 - 7 hours. This difference is explained by the fact that butterfly sprinklers have short ranges of distribution (Photo 24) and higher application rates. Butterfly sprinklers require a continuous presence in the field while impact sprinklers have lower application rates and are thus less labour-intensive.

WETTING PATTERN

Uniformity of distribution is a critical factor when evaluating sprinkler performance. Therefore, an attempt was made to measure the uniformity of water distribution for different sprinklers, "jua-kali" and imported, in controlled conditions. The results[3] indicated coefficients of uniformity below 70% for all sprinklers.

The field studies indicate that the low uniformity of single sprinklers is partly offset by the irregular pattern of sprinkler movements in the field and by the short irrigation intervals. The flexibility of the system allows farmers to act swiftly as lack of uniformity on soil wetting and crop growth become apparent.

Though neither farmers nor artisans are able to measure uniformity, both recognise the problem and attempt, in different ways, to improve the wetting pattern:

- In windy conditions, farmers tend to choose sprinklers that produce larger droplets to minimize drift losses and to achieve a more circular wetting pattern.
- Sprinklers with a fixed frame tend to produce a "shaded" area in correspondence to the wings. Artisans have tried a number of strategies to reduce this shading effect, which include using a singular wing and different devices to make the sprinkler rotate (Illustration 25, Photos 26, see also 10).
- Wetting the area close to the stand seems to be a major problem for reaction sprinklers. The holes drilled on the horizontal segment of the pipe near the central axis have this function as well as allowing the farmer to reduce pressure when it is too high, (see photos 13 & 14).

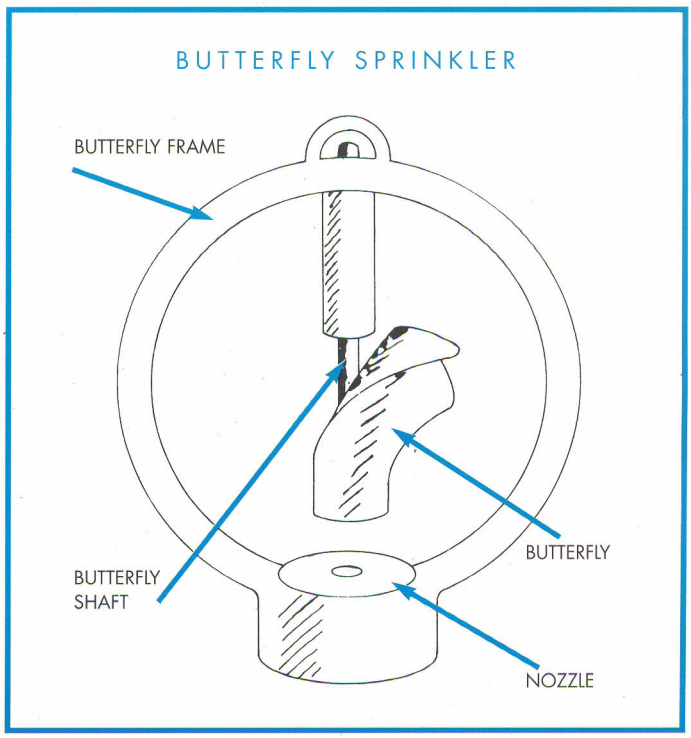


ILLUSTRATION 25: BUTTERFLY SPRINKLER

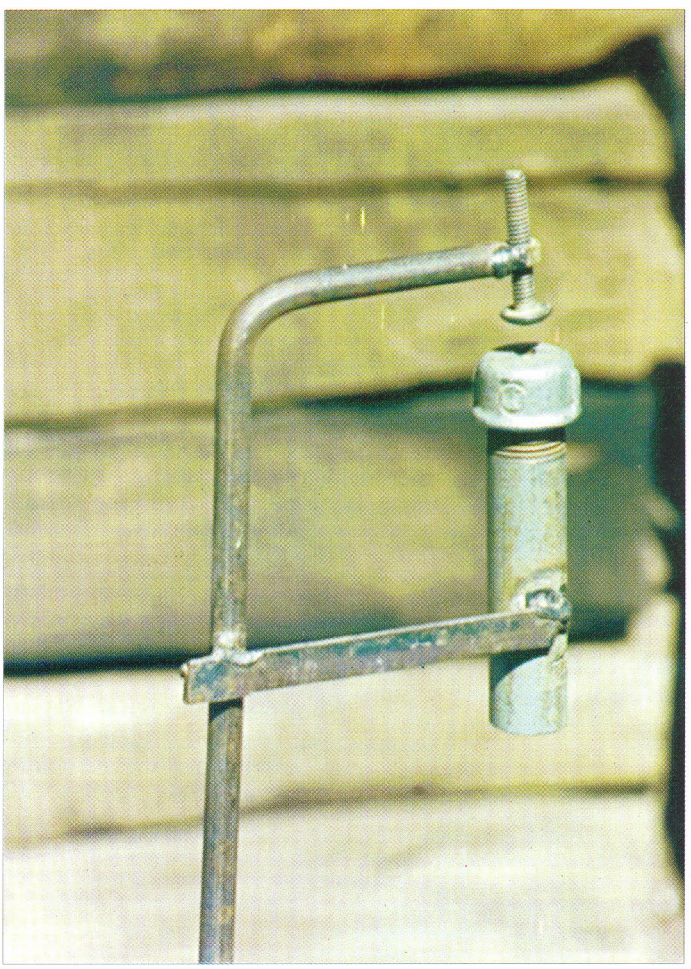


PHOTO 26: STATIC BUTTERFLY, STATIC TYPE WITH ONE WING (UNKNOWN ARTISAN)

On-Farm Application Efficiency:

On-farm application efficiency is influenced by evaporation and drift losses, deep percolation losses and leakages in the in-field system. High evaporation and drift losses are apparent when sprinklers are used during windy days. The losses are increased when high pressures cause butterfly sprinklers to produce very fine drops.

Photo 27: The most delicate parts in imported models

Also, in-field systems usually consist of flexible plastic hose-pipes which, with time, develop leaks at connection points or through cuts in the material. Farmers do not appear to be very concerned by these losses since they then avoid irrigating the areas which are already wet as a result of the leakage. Finally, deep percolation losses are not important since, because of the short irrigation intervals, the water dose applied seldom goes below the root zone of the crops.

The "Jua Kali" Artisans

Most sprinkler manufacturers are non-specialised artisans who do small repairs and produce a variety of items such as beds, window frames, and agricultural implements. A few of these artisans have become specialised in irrigation-related items such as sprinklers and pipe fittings (Photo 28).

PHOTO 28: A WORKSHOP SPECIALISING IN THE MANUFACTURE OF IRRIGATION IMPLEMENTS

Manufacture of sprinklers is a relatively recent undertaking which has followed the introduction and spread of imported models. When farmers started bringing in imported models for repair, the artisans realised that those models had some structural weaknesses which were hard to fix (see Photo 27). With the growing demand for sprinklers, they started to manufacture their own models with locally available materials, progressively modifying them according to farmers' needs and their own observations of performance and durability. Changes included the materials used, the production technology and the shape of the different elements.

Most of the artisans operated individually or in association with one or few family members. Some artisans have larger businesses which allow them to employ several workers.

The number of sales depends on local demand, on the artisans' ability to implement an aggressive marketing strategy, on the price and quality the manufacturer is able to offer, and on production capacity. Artisans living in the oldest irrigation project areas have had more time to develop their skills. However, as manufacture has improved, models have become more and more resistant and tend to last very long. In some areas therefore, with sprinklers lasting longer, demand has dropped sharply in recent years. The more skilled artisans, for whom sprinkler-production is important as a business, have started marketing their products outside their own areas. The higher demand is mainly from schemes where irrigation has started recently, and where local artisans have not yet developed suitable models.

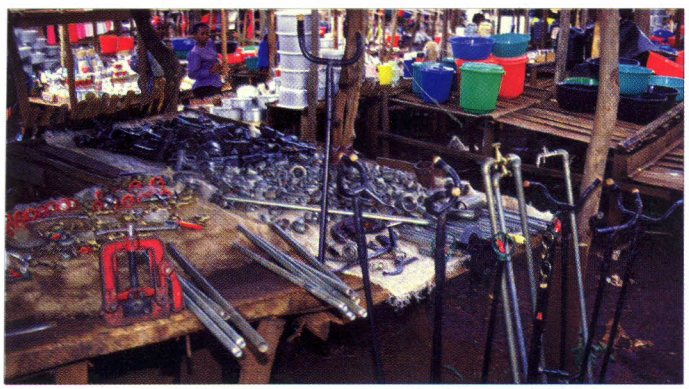


PHOTO 29: A TYPICAL RETAIL OUTLET

PHOTO 30: A TYPICAL RETAIL OUTLET

Most artisans have some type of retail outlet and are able to sell between 100 and 400 pieces per year. Those who have developed their own distribution network and market their sprinklers through rural hawkers or urban retailers can secure higher sales (Photos 29 & 30). One artisan in Embu, who declared marketing through 26 retail outlets in Embu, Kerugoya, Nyeri and Nanyuki towns, reported sales of up to 2,000 pieces a year. Urban artisans advertise their business using signboards (Photo 31, see also Photo 28) and are more likely to be able to display their implements during the agricultural show which takes place annually in their town.

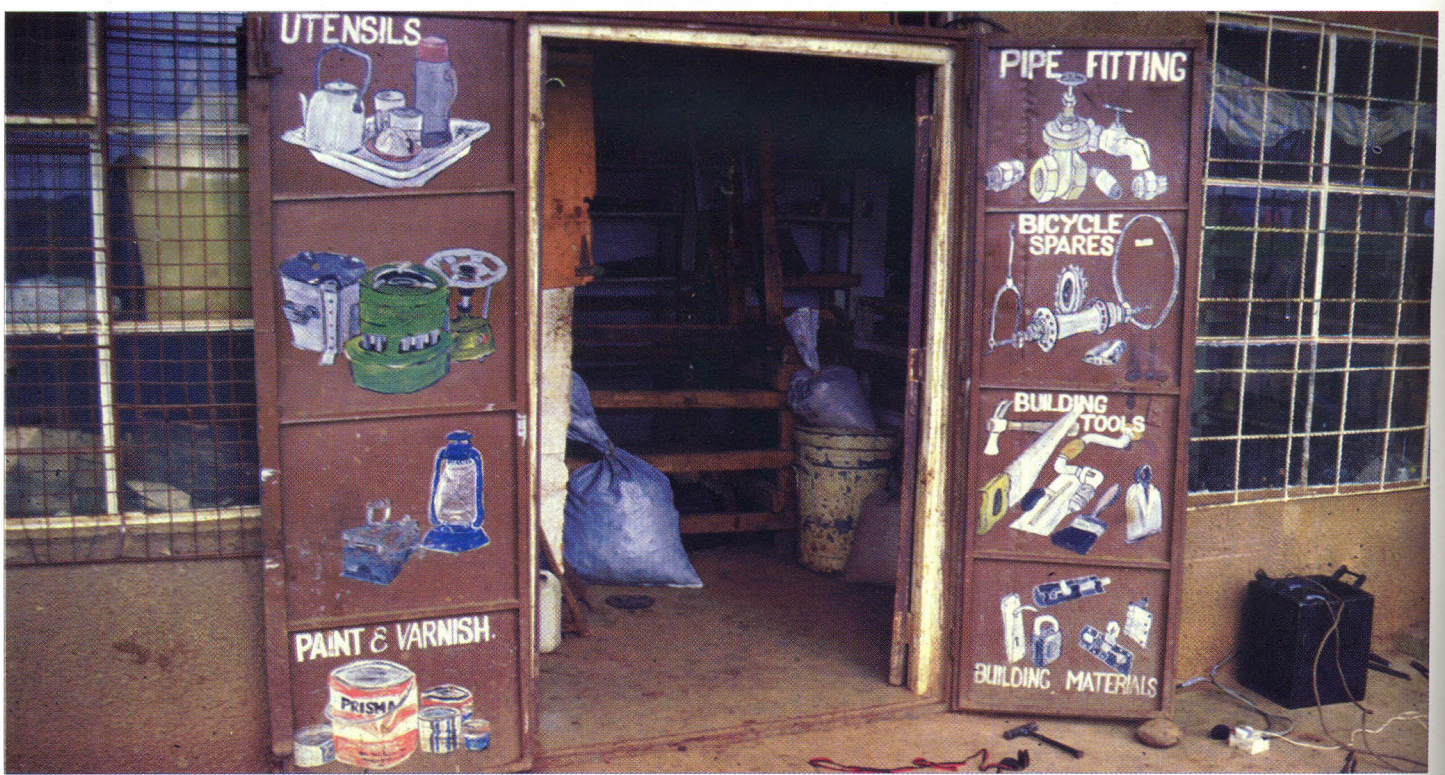


PHOTO 31: A SHOP IN TIMAU, MERU.

The price of sprinklers depends on the cost of materials, the time needed to procure those materials and on the time used to manufacture each piece. Time of manufacture is a function of the technology employed which, in turn, is influenced by the materials used and by the tools available. The case of Silas Njue illustrates the pricing process and some of the factors affecting price.

Box 1

Silas Njue (Timau, Meru)
Butterfly Metal Fixed Frame

This model has undergone several modifications. Five years ago the shaft holding the spindle was made of rubber and glue (Photo 32). The artisan stopped manufacturing that model because it was very time-consuming; he could make only 3 sprinklers in a day. He substituted the rubber shaft with a welded metal one (Photo 33). The next modification occurred when he decided to substitute the PVC pipe and nozzle cap respectively with a GI stand and a metal socket.

To make the stand he uses $^1/_2$" (approx 12mm) metal tubes from used safari beds. One safari bed costs 200Ksh. and from it he can make 12 stands. By utilising used materials he can sell his sprinklers, including the stand, for 200Ksh. each. This is a relatively low price, so petty traders from outside the area buy them in bulk to resell them. Used safari beds are increasingly difficult to find; if he has to buy new pipes he will have to sell his sprinklers at 300 - 350Ksh. each because a new $^1/_2$" pipe costs approximately 600Ksh. and he can only make 7 stands out of it.

He does the riveting at home, but for the welding he must go to Timau where welding the frame costs 25Ksh. per sprinkler. He judges the weakest part to be the riveted junction between spindle and butterfly, though he claims that the sprinklers have a very long life (the model in the picture is 5 years old and has never been repaired). He also repairs sprinklers and he charges 40Ksh. to rivet the butterfly and 70 - 80Ksh to replace both the butterfly and the spindle. Nevertheless, he claims that these repairs are only necessary on imported models; farmers have never come for repairs of his sprinklers, though he gives a one year guarantee when he sells them.

He also says that farmers prefer his model because "imported ones take two hours to wet a place, mine take only 1.5 hour".

He estimates his production capacity at 15 sprinklers per day and reports sales of between 60 and 100 sprinklers per month during the dry period, totalling yearly sales of 400 - 500 pieces. To increase sales he lowers the price to 150Ksh. per piece for petty traders who come from Timau, Nanyuki and Naromoru towns, to buy in bulk.

Sprinklers represent his main off-farm income which "I use to finance my domestic needs and farm inputs".

Photo 32: Silas Njue, first model of Butterfly Sprinkler

Photo 33: Silas Njue, second model of Butterfly Sprinkler.

Box 2
Arkangelous "Ali" Nderi (Karurumo, Embu)
PVC Reaction Type Sprinkler

Ali is a farmer as well as a manufacturer who produces an estimated 150 sprinklers per year. He manufactures his model out of a $^1/_2$" (approx. 12mm) PVC pipe. His technology is extremely simple and he only needs a saw and a knife plus some glue and a heat source. Out of a 20ft. (approx 6m) pipe, he can make 12 sprinklers, each of which he sells at 70Ksh. He can manufacture a sprinkler in less than one hour. His sprinklers are sold within the location, either through local shops or directly to customers who come to his farm. Demand comes mainly from people who use their domestic water supply, but the sprinklers can also be used with pumps. However, when the pressure is too high, several sprinklers must be operated at once to avoid ejection of the extremities. The extremities are not fixed so their orientation can be changed in order to vary the size of the irrigated area. For this reason replacing one extremity free is part of his marketing strategy.

With time he has introduced two modifications: he now drills a hole in the middle of the horizontal pipe to irrigate in the proximity of the sprinkler, and two holes at the extremity, one of which can be closed when pressure is low.

Used with a hand pump (which he himself manufactures), the sprinkler can distribute water at a maximum distance of 2m; at higher pressures, for instance when used with a diesel pump, the distance of throw is higher (approx. 4m) but the sprinkler rotates very slowly so that the application rate should remain approximately the same.

Photo 34: Arkangelous Nderi known as "Ali", Karurumo, Embu

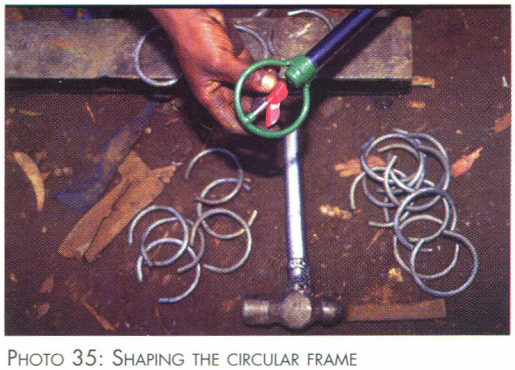


Photo 35: Shaping the circular frame

Most butterfly models are made of metal parts, often of different origins, but use of different materials on the same sprinkler is not uncommon.

For the wings, some artisans use flat iron bars 1.5" (approx. 40mm) wide, while others use round bars of various sizes. The shape of the wings is usually circular or oval, (Photos 35, 36 & 37), but squared frames are quite common (Photos 38 & 39).

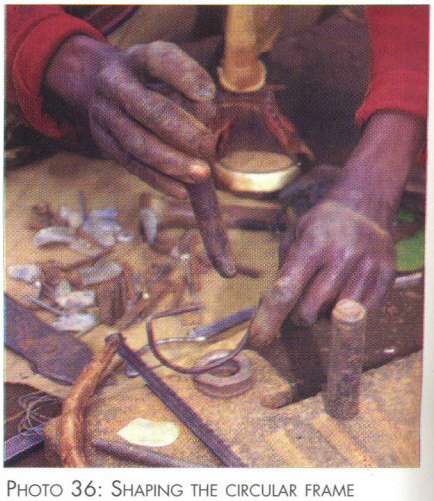
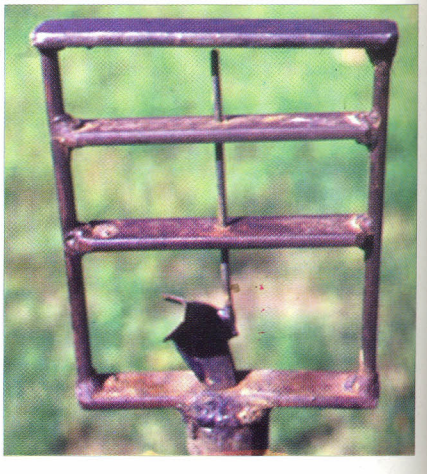


Photo 36: Shaping the circular frame

Photo 37: Circular Frame Sprinkler



Photos 38 & 39: Butterfly Sprinklers, metal models with fixed square frames

The shaft holding the butterfly can be made with a thin metal bar, a nail, a piece of wire, or even a used biro pen. In Gitongo market, several artisans have recognised that customers often only require replacement of the external part of bicycle pedals. They recycle the pedal axles and use them to manufacture the spindle which holds the butterfly (Photo 40, see also Photo 19).

The nozzle is typically drilled in a GI socket, but PVC sockets or bottle caps can also be used. According to the material used to form the cap, the nozzle can be made using a nail or a drill, and always has a circular shape.

The butterfly is the part that is most consistent in terms of materials used. It is usually manufactured out of a small piece of aluminum plate, which is easy to twist to the desired shape. Sometimes recycled plastic moulded through heat is used. Bending the butterfly and fixing it on the shaft are probably the most delicate operations since the correct performance of the sprinkler depends on the butterfly.

PHOTO 40: TWO DIFFERENT SHAPES OF A BUTTERFLY

PHOTO 41: BENDING THE BUTTERFLY

Over time, every artisan has created a particular shape for the butterfly and has developed his own system to standardise this shape. This extends from simply repeating a series of well- defined movements, eg. beating the metal sheet against the corners of an iron plate (Photo 41), to constructing simple devices (Photo 42), to building machines which can produce standard parts (Photo 43).

PHOTO 42: PATRICK M'BIJUE MBUI (MERU) AND HIS MODEL OF METAL BUTTERFLY SPRINKLER WITH FIXED FRAME. IN HIS RIGHT HAND IS THE DEVICE HE USES TO BEND THE BUTTERFLY.

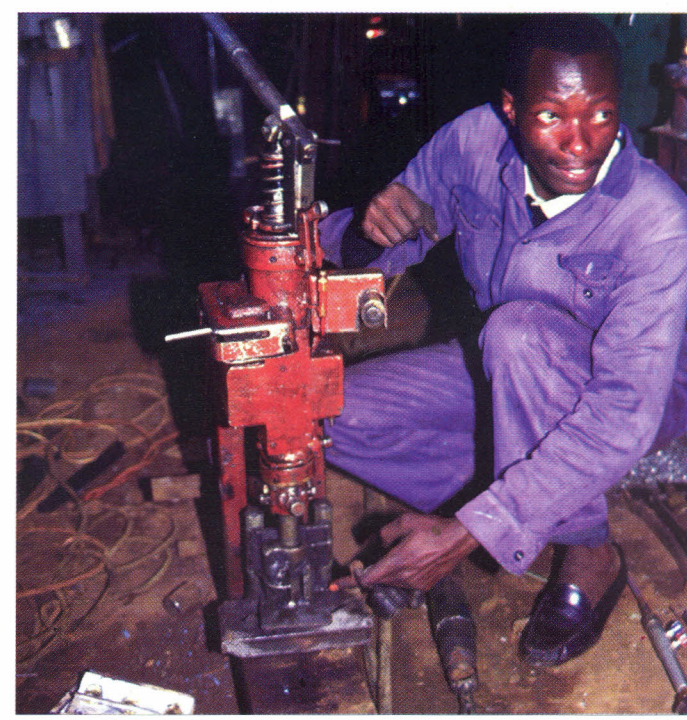


PHOTO 43: KIMANI (BROTHER OF KAMAU, EMBU) WITH HIS OWN DESIGN OF MACHINE TO CUT AND SHAPE THE BUTTERFLY

PHOTO 44: ALIGNMENT OF THE BUTTERFLY IS NOT ALWAYS EASY.

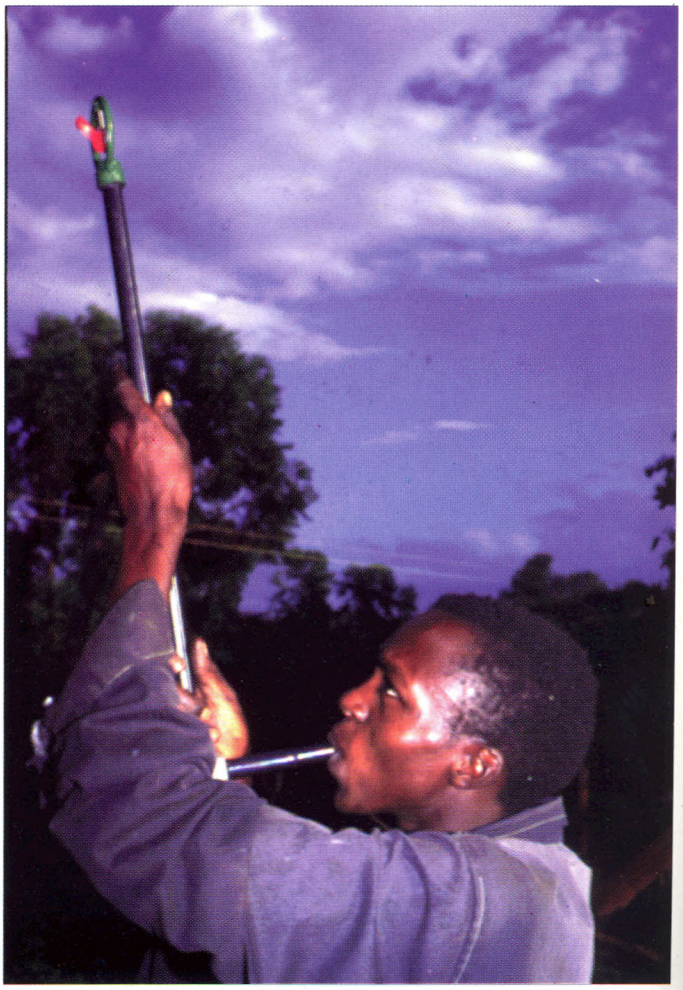


PHOTO 45: TESTING THE NEW SPRINKLER

PHOTO 46: TESTING THE NEW SPRINKLER

Fixing the butterfly on the shaft is difficult because alignment for correct rotation depends mainly on the shape of the butterfly.

Most artisans can achieve this easily through experience, and even when the process may not be obvious to an outsider, results are effective (Photo 44). Rotation is tested immediately by blowing into the sprinkler (Photos 45 & 46).

PHOTO 47: PLASTIC BUTTERFLY SPRINKLER MADE WITH SCRAP MATERIALS

PHOTO 48: PLASTIC BUTTERFLY SPRINKLER MADE WITH SCRAP MATERIALS

While most artisans purchase at least some of the butterfly sprinkler components, some also manufacture sprinklers entirely with scrap materials. In Meru, school children are able to produce very simple models uniquely with a biro pen, a bottle cap, rubber and wire (Photos 47, 48 & 49).

Butterfly sprinklers, and to a lesser extent static sprinklers, have a variety of models, while the reaction type is more uniform in terms of materials and technology. It is always made out of a half inch PVC pipe, differences between models being only the bending of the horizontal pipe.

PHOTO 49: PLASTIC BUTTERFLY SPRINKLER MADE WITH SCRAP MATERIALS

The "Jua Kali" Artisans

The technology employed depends on the materials used and on the tools which are available. Different levels of technology and organisation of the production process have been observed. Most "Jua Kali" produce one sprinkler at a time, with simple tools and often with scrap materials (Photos 50 & 51). In some cases, power to run tools such as a welding machine or a drill is not available, and the artisan is forced to complete the sprinkler elsewhere at a cost.

PHOTO 50: GICHUKI MAINA "KARAVUI", IN HIS WORKSHOP (NARO MORU)

PHOTO 51: ANGELO KATHIA (MERU) WITH THE INSTRUMENTS HIS USES TO MANUFACTURE HIS SPRINKLERS

While many artisans still manufacture most of the parts, others assemble ready-made parts.

One artisan in Embu town has developed and industrial-like production system by designing and constructing his own machines to manufacture the single components of the sprinkler, which he later assembles.

In general terms, each artisan has, to different degrees, been able to adjust his models following his own observation and feedback from farmers, and by responding to changes in prices and availability of materials (see Photos 52 & 53).

More resistant models have evolved, as well as models which are easier and cheaper to repair. For instance, one artisan welds the most delicate parts with brass so they can be repaired more easily. However, the part which is more prone to wearing out is the spindle supporting the butterfly (see Photo 54).

Conclusion

PHOTO 52:

The Kenya Government policies for the Irrigation Sector have played a major role in encouraging the participation of local entrepreneurship, both in infrastructure construction and in services provision.

As irrigation system design has shifted from being a demand-orientated to supply-orientated, engineers have been able to concentrate on providing water up to the plot boundary, leaving farmers maximum flexibility in choosing their in-field system.

As a result, farmers have been encouraged to look for low-cost, easy-to-maintain technologies. The informal sector has responded admirably to this challenge, and sprinkler technology has developed rapidly through a continuous process of "trial & error" - a process stimulated both by access to imported products and by farmers' demands for cheap and reliable implements.

PHOTOS 52 & 53: EVOLUTION OF SPRINKLERS

PHOTO 54: WEAR 'N' TEAR

Note 1: "Jua Kali" in Kiswahili literally means "fierce sun". It is also the nickname given, sometimes derogatorily, to the artisans in the informal sector.

Note 2: US$1 equals approximately 45Ksh (November 1994).

Note 3: The test, which was carried out in 1991 in the University of Nairobi, included 2 imported butterfly sprinklers, 5 "jua-kali" butterfly sprinklers, 1 static type and 1 reaction type.

Addresses of Jua Kali

Disabled Children's Home,
Catholic Mission,
P.O. Box 180,
Naromoru

Gichuki Maina ("Karavui"),
Kahuho,
P.O. Box 182,
Naromoru.

Kamotho, Kahuho,
P.O. Box 182,
Naromoru.

Samuel Gichuhi Maina,
Naromoru Market
P.O. Box 12,
Naromoru.

Ruben Mureithi,
Naromoru Market,
c/o Isaac Ndungu Inuthia,
P.O. Box 4,
Naromoru.

Arkangelous Nderi ("Ali"),
Kariru Sublocation,
Kieni South Location,
Runyenjes Division, Embu District,
P.O. Box 31, Karurumo.

Kamau,
Jua Kali Irrigation Services,
P.O. Box 235, Embu.

Aaron M'Turuchiu & Steven Mwenda,
Katheri Market,
P.O. Box 1919,
Meru.

Patrick M'Bijue Mbui,
Katheri Market,
P.O. Box 14,
Meru.

Cyrus Kimathi,
c/o Cornelius Murithi,
Katheri Market,
P.O. Box 1248,
Meru.

David Muriungi,
Githongo Market,
P.O. Box 10,
Githongo,
Meru.

John Magiri,
Githongo Market,
P.O. Box 370,
Githongo,
Meru.

Erastus Murungi,
Githongo Market,
c/o Githongo Dairy,
P.O. Box 6,
Githongo, Meru.

Joseph Gituma Kwiriga,
Githongo Market,
P.O. Box 602,
Meru.

Franklin Kinyua,
Githongo Market,
P.O. Box 602,
Meru.

Silas Njue,
P.O. Box 124,
Timau, Meru.

Kirimi P. Mwerebew,
Kiguru Scheme,
P.O. Box 124,
Timau, Meru.

Angelo Kathia,
Kiambogo Scheme,
P.O. Box 124,
Timau, Meru.

Benson Kibebe,
Sagana Irrigation Scheme,
P.O. Box 516,
Karatina, Nyeri.

Sospeter Kabua,
KBL Malting,
Enterprise Road,
Nairobi.

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Meru District.

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