IRONWORKING AND DEFORESTATION IN PRE-COLONIAL AFRICA: THE CASE OF KONDOA IRANGI, CENTRAL TANZANIA

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Abstract

Pre-industrial ironworking in Africa (and elsewhere for that matter) consumed large quantities of wood and charcoal especially during smelting. As the result, iron smelting has often been associated with deforestation. In fact, this was one of the two main excuses used by colonial authorities to repress local production of iron in a number of places in Africa during the early twentieth century; the other one being protection of European-made iron products. Iron smelting was directly linked with deforestation and other resultant environmental perils such as soil erosion and desertification. Using archaeological and ethnographic data from Kondoa Irangi in central Tanzania, this article critically examines the validity of associating iron metallurgy with deforestation, and attempts to dissociate myth from reality.

Keywords: *ironworking, deforestation, pre-colonial Africa*

1.0 Introduction

Incontrovertible evidence, available at present, shows that metallurgy in Sub-Saharan Africa is about three millennia old. It started with the working of both iron and copper almost simultaneously at such places as Do Dimmi in Niger (1000 BC) and Taruga in Nigeria (6th century BC) for iron; and Agades and Azelik in Central Niger Republic (900-300 BC) and Akjoujt in Western Mauritania (800-200 BC) for copper (Herbert, 1984; Killick *et al.*, 1988; Bisson, 2000; Alpern, 2005). Although bronze and brass alloys are also reported to have been produced in West Africa and South Africa they never spread in space or time to any notable scale (Bisson, 1997; Mapunda, 2013a).

Once established, the production of iron, and to a certain extent copper, continued until the advent of colonial invasion in the late nineteenth century AD. However, the manufacturing industry (led by metallurgy) along with religious beliefs were among the first local institutions to be suppressed by the colonial powers. While religions were inhibited in the name of the one God who came with Christianity,

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metallurgy was suppressed in the name of the main mission of colonialism – economy. Colonialists wanted to stop local production of industrial products in order to safeguard the market of European products. Jules Méline, the then French Minister for Agriculture, once put this point very clearly when addressing the Annual Congress of the Chamber of Industry and Agriculture on 8th March 1899:

> *La France voulait décourager par avance les tentatives industrielles qui pourraient se faire jour dans nos colonies, obliger en un mot nos possessions d' outré – mer à s` adresser exclusivement à la métropole pour leurs achats de produits manufacturés, et à remplir, de gré ou de force, leur office naturel de débouchés réservés, par privilège, à l' industrie métropolitaine.*
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> **English Translation:** [France wishes to discourage from the outset, all attempts in industrialisation which may develop in our colonies and oblige our overseas possessions to develop entirely on the metropole for their manufactured products, in order to fulfill willingly or by force their natural obligation to the metroplole.] (Quoted in Niville Zebedayo Reuben, 2012: 77-78).

Obviously, confessions of the kind quoted above were more openly made in Europe than in Africa where colonial masters were less transparent, placing humanitarian and spiritual factors at the fore! Various pretexts were used to cover up their ill intentions. In the southwestern part of Tanzania, for example, Marcia Wright notes that colonial authorities suppressed the production of iron on the pretext of environmental control. It was argued that the process required large amounts of fuel wood and charcoal, hence was destructive to forests (Wright, 1985). In fact the same fate befell shifting cultivation and hunting, both of which were banned on being "environmentally destructive" (Noe, 2009).

On the surface, one may find the colonialists' argument logical and convincing. Commending the British colonial government for banning iron working in Ufipa, one of the metallurgical powerhouses in pre-colonial Tanganyika, R. C. Greig, had this to say:

> Of more importance, however, is the denudation of forest which is necessary for making the charcoal, and if the industry were to continue to flourish the Weald of Kent would have its parallel in Fipa. If the craft is dying out the forests are surviving and there is no doubt which is of the greater ultimate value to the tribe (Greig, 1937:81).

Apparently, Greig was not aware that there was a place in Tanganyika at the time where he could have drawn a better parallel with the Weald of Kent than Ufipa; and that was Haubi, Kondoa Irangi, Central Tanzania (Fig.1). This was not only one of the major centres of ironworking in the region but also by then it had already been severely affected by a combination of sheet, rill and gully erosion. Erosion at Haubi was and still is so severe and spectacular that the place has become a tourist attraction. Bare soils and badlands with gullies as deep as 20 m (Plate 1) characterise the Haubi landscape. It is because of its severity that soil erosion there has attracted government attention since the colonial period with a number of conservation programmes (Lane, 2009). In addition to government projects, a number of researchers including soil scientists, paleogeographers, paleoenvironmetalists, botanists, and archaeologists have converged at the site, each trying to examine the problem from one's own viewpoint and expertise (Mung'ong'o, 1990, 1999; Erickson, 1998; Lane, 2009).

This article is a product of one of such efforts as stated above. It emanates from an archaeometallurgical research conducted between 1998 and 2001 with the aim of establishing whether or not ironworking, the remains of which are commonplace in Haubi and elsewhere in Kondoa District, caused or intensified soil erosion at any particular time in the history of the area. In responding to this question, the article begins with a presentation of the time frame of soil erosion as reconstructed by soil scientists using optical stimulated luminescence (OSL) dating of the colluvial and alluvial deposits. This is followed by a review of ironworking in the area before examining the relationship between ironworking and deforestation. Finally, the article re-examines actual and potential causative links between ironworking and deforestation by using Kondoa Irangi, in Central Tanzania, as a case study. In so doing, truth and fallacy of the matter are revealed.

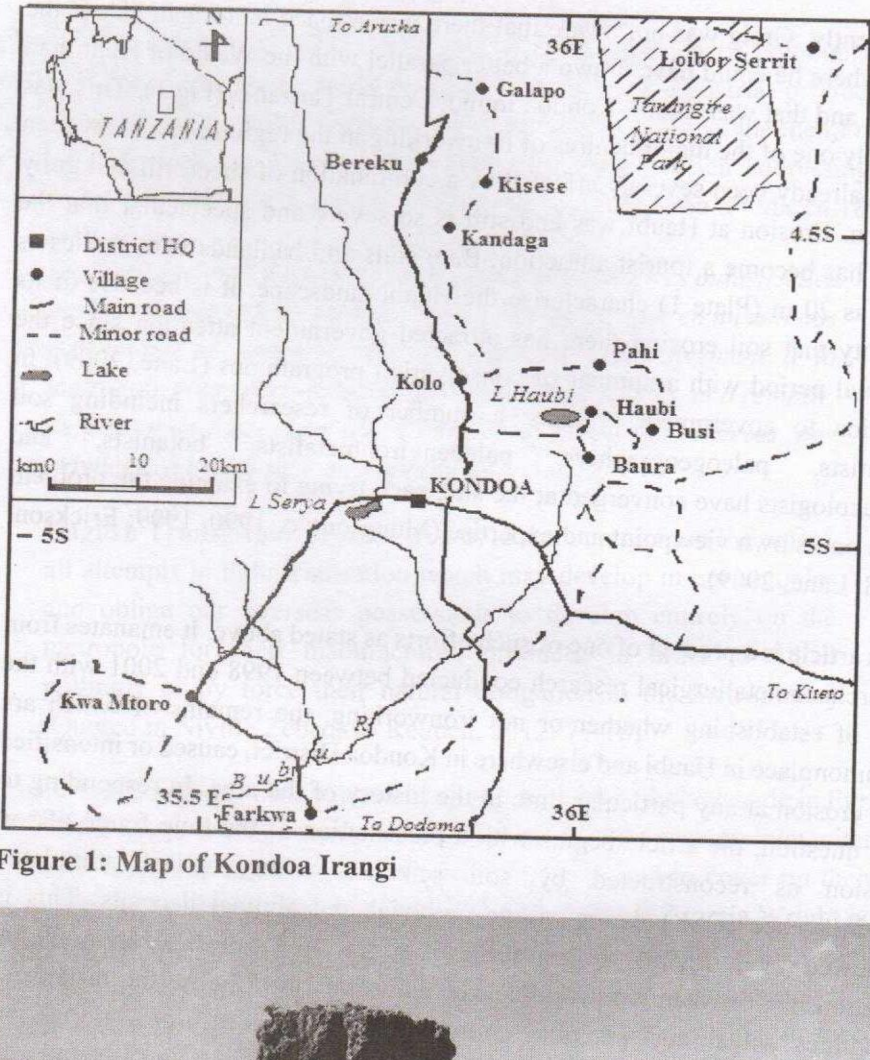

Figure 1: Map of Kondoa Irangi

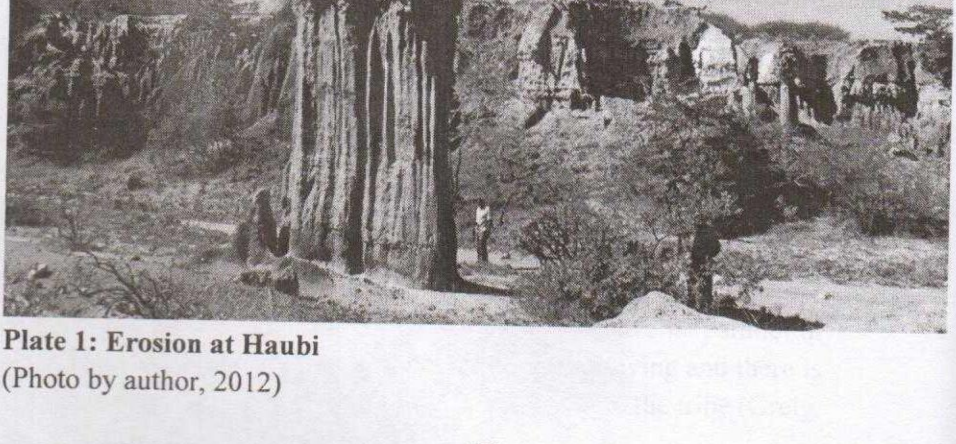

Plate 1: Erosion at Haubi
(Photo by author, 2012)

2.0 Soil erosion in Kondoa: A historical overview

Kondoa Irangi is a semi-arid land with average rainfall of 500-800 mm, which often falls in heavy pours, thus highly erosive. The natural vegetation comprises a mix of miombo woodland, degraded low tree, and shrub savanna with some mosaic forest especially along river valleys almost all of which are seasonal (Lane, 2009). Most of these rivers drain into inland swamps and lakes such as Serya and Haubi (Fig.1). Through time, the seasonal drainage systems have piled up deep soil deposits in these lakes and swamps that have become informative agents for climatologists, paleoenvironmentalists, and soil scientists who would obtain samples for various purposes including OSL (Mung'ong'o, 1990; Erickson, 1998; Eriksson *et al.*, 1998).

OSL measurements in the Haubi catchment area indicate two major erosion periods during the last 15,000 years (Eriksson *et al.,* 1998). The first phase is dated between 14,500 and 11,400 years ago. This is considered to have been caused by climatic shift from dry to wet conditions that took place before Holocene. However, as Eriksson and co-workers note, it is likely that at this stage there was an intensification of already operating processes, which is characteristic of soil catenas in the seasonally dry tropics, rather than beginning of the process. During this phase, sandy colluviums were deposited in shallow depressions in the upper and middle pediment slopes. This erosion phase was succeeded by a long stable period during the early to mid-Holocene when mature soil profiles, with argillic horizons or with lateritic ironstone, formed on the old colluviums (Eriksson *et al.,* 1998). Human influence during this time, if any, was probably negligible.

OSL dates suggest that the second erosion phase started not later than 900 years ago, and has continued, albeit with fluctuations, until today. The early stage of this phase was associated with relatively large gullies which used to feed alluvial fans formed on the middle pediment slopes. However, sheet and rill erosion were probably the dominant erosion processes at this time, whilst other areas were still under a stable vegetation cover and entirely unaffected (Eriksson *et al.,* 1998). Continuing erosion, probably including shallow gully formation, accounted for the deposition of the better-sorted red colluvium circa 600 years ago. Apparently, gullies progressively deepened and extended to cover the entire length of the pediment slopes while at the same time extensive sand fans formed at the mouth of the large gullies, on top slopes.

There is also an indication that during the following 300 years (c. 600-300 years ago) deep gully incisions took place into the saprolite and weathered gneiss (Eriksson *et al.,* 1998) which must have fostered the release of rich titaniferous ores in form of sand deposits along gullies and river banks, hence becoming a blessing for iron smelters in the area. Based on the mineral magnetic analysis and sedimentation rates, periods of high sediment deposition in the more recent past started around the turn of the twentieth century, and increased gradually after around 1935, with particularly high rates between 1945 and 1950, and again from 1955 to the present (Eriksson, 1998).

By the time the second phase took place, the current inhabitants, the Rangi people, were already living in the area and ironworking was being practiced (Kessy, 2005). However, the presence of people and ironworking is not by itself enough a reason to associate the appearance of or intensification of soil erosion with human influence. This is because Kondoa Irangi is not the only place that was inhabited at this time. Much of Tanzania was by then already settled by people of the Bantu origin and ironworking was commonplace, and yet soil erosion is not equally intensive across the country. Hence, Kondoa must have had factors that were either time-specific or space-specific that were responsible for its severe erosion.

Researchers, especially soil scientists who worked in the area in the 1990s drew a number of hypotheses in regard to the intensification of soil erosion in Kondoa. These included climatic fluctuation, farming, and animal keeping (Christiansson, 1981; Östberg, 1986; Mung'ong'o, 1990, 1999; Yanda, 1995). However, as survey research continued in the area and more and more metallurgical remains especially slag and tuyere fragments were unraveled, ironworking was added in the list of hypothetical causes. Thus, soil scientists felt the need of incorporating an archaeometallurgist in the search for factors for soil erosion in the area. That is how I became involved with the research on soil erosion at Haubi. The findings from that work constitute the core of argumentation in this article.

3.0 Origins: Peopling and ironworking

Archaeological records show that human settlement in the Kondoa Region goes back to the Acheulean industrial complex, over a million years ago. Willibald Lema characterises Haubi as one of the most important Early Stone Age sites of Tanzania (Lema, 2009). However, there is no evidence of direct intensive land use back then. We can reasonably extrapolate that the Acheulean tool makers (presumably *Homo erectus*) must have been nomad hunters and gatherers, whose impact on the environment must have been overly marginal. The same perhaps continued during the Middle Stone Age as the artifacts seem to be quite scattered. The situation changed during Later Stone Age (LSA). Microlithic artifacts are increasing in the archaeological record, showing increased resource exploitation in the area, which may also mean population increase. Although LSA in the area started around 18,000 years ago it spread more widely from 3,500 to 1,800 years ago when possibly agriculture and, a little later, iron technology took over (Masao, 1979; Kessy, 2005, 2013; Lane, 2009).

The continuum observed in the archaeological record may not necessarily mean a continuum of ethnicity. In other words, the current inhabitants of the area, the Rangi, are not necessarily descended from the makers of the Acheulean or even microlithic tools evident there. This caution withstanding, attempts of establishing the peopling of the area show that the Rangi claim to have originated from Haubi, as P. Baustark wrote at the very beginning of 20th century: "Very little is known about the early history of the Rangi people beyond the fact that they have a tradition that they dispersed from the area near Lake Haubi" (Baumstark, 1900:60, quoted in Liesegang, 1975:95). In 1974, while working under the direction of Fidelis Masao, Gerhard Liesegang observed that the pottery remains from Haubi "had little in common with present-day pottery" when compared to those from other sites in Kondoa Irangi. This led him to support Baumstark's view that Haubi was the original settlement of the Rangi people (Liesegang, 1975:95).

Recent research also shows a relatively early age of the Haubi pottery. As Lane notes, the few diagnostic ceramics from Haubi "exhibit typological similarities (notably the use of beveled rims) to early farming community Lelesu ceramics from Sandawe, and Kwale wares from Pare and Usambara Mountains, Kilimanjaro, and adjacent areas to the northeast" (Lane, 2009: 470).

Baumstark was also among the first researchers to report about ironworking of the Rangi people. He gathered that ironworking both smelting and blacksmithing had been practiced in three main centres: Bussi (Fig.1) Konduzi, and Uriwa (the last two are yet to be relocated ethnographically) (Baumstark, 1900, cited in Liesegang, 1975). He informed that smelting in the area produced raw iron (bloom) using magnetite sand collected from river beds and processed it in relatively small furnaces with the aid of six to eight bowl bellows. After it cooled off it was broken into pieces, cleaned of its charcoal and slag and normally sold to blacksmiths who would forge various weapons and tools that were sold to both internal and external markets (Liesegang, 1975).

Subsequent research has revealed many more sites, showing that ironworking was a common industry in Kondoa Irangi. In addition to the three centres, remains of iron technology, including furnaces (bowl type), slag and tuyeres have been found around Baura, Haubi, Pahi, and Kisese (Liesegang, 1975; Masao, 1976, 1979; Lane *et al*., 2001; Kessy, 2005, 2013; Lane, 2009) (Fig.1). While some products of the said technology, including hoes, arrows, spearheads, knives, axes, billhooks, and many others were consumed locally by the farming Rangi people, a good amount of tools and weapons was exported to the neighbouring communities, including the Gogo to the south; the Sandawe and Nyaturu to the west; and the Maasai to the north, in exchange with livestock, grain and salt (Kjekshus, 1996). The Rangi hoes are said to have been of superior quality and therefore attracted the interest of more customers than hoes coming eastward from Unyamwezi through the caravan trade. On account of that, Kondoa Irangi is reputed for being the most important production and trading centre of iron and iron products in the whole of Central Tanzania (Kjekshus, 1996).

One question researchers studying the soil erosion of Kondoa have been interested with has been the origins of iron technology in the area. The answer to this question is central in establishing the causative linkage between ironworking and soil erosion. Fidelis Masao is one of the early researchers to attempt answering this question. Basing his reasoning on the location of metallurgical remains, particularly slag, in the stratigraphic sequence of the pits he excavated in some rock shelters, Masao (1979:38) came to the conclusion that iron production had not been introduced in Kondoa until AD 1500, or even later. Interestingly, his estimation has come to tally closely with C14 dates obtained from recent research in the area. Lane *et al*. (2001) at Haubi and Emanuel Kessy at Baura and Pahi (Kessy, 2005, 2013) have produced dates ranging from 1000 BP to the 19th century. At the same time the earliest evidence for settlement in form of daub, post-holes and pottery date to ca. 2000 BP (Lane, 2009). This is site No.16, located on the middle pediment slope, west of Lake Haubi. This set of data suggests that iron working was adopted almost a millennium after permanent settlement started in the area, and hence confirms further the extrapolation made above from Liesgang's and Lane's argument that land overuse, possibly from repeated farming without or with very short fallowing period, could have had a stake in land denudation at Haubi (as shall be expounded later).

Both archaeological and ethnographic evidence show that the iron smelters around Kondoa have been using bowl furnaces through time. Further examination, however, identifies two morpho-types, which seem to be contemporaneous. The first type is what we could call a typical bowl furnace: a simple, cylindrical hole, with a flat floor and vertical edges, about 50 cm in depth and breadth (Plate 2). The second seems to be atypical in that it would be built on a slope and would have a relatively shallow pit, about 30 cm deep at the centre. The up-slope side of the rim has a short clay wall of about 10 cm high, while the down-slope side is left open, seemingly for slag tapping (Plate 3). Carbon 14 dates place the two in the 18[th] century (Kessy, 2005, 2013).

So far no furnace has been found at Haubi, despite the effort of researchers. However, ethnographic information (Shaaban Kideso, informant, 1998) indicates that the smelters here used bowl furnaces of morpho-type one. The absence of furnace debris in the Haubi area seems to support the ethnographic information that bowl furnaces (especially of type one) were used at Haubi. So far there is no evidence to show that it was not the main type since the introduction of ironworking in the area was over 500 years ago.

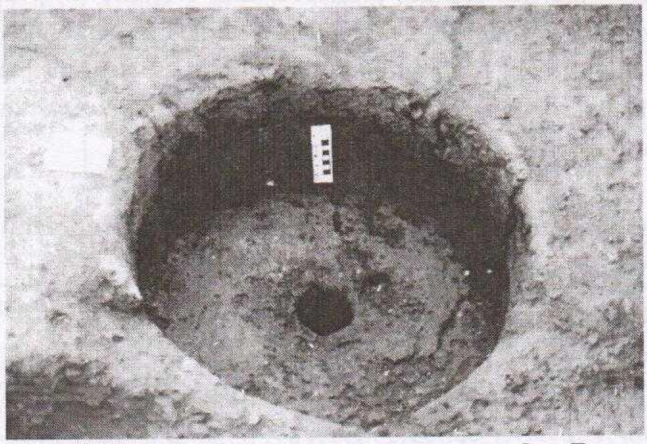

Plate 2: Flat-bottomed simple bowl furnace excavated at Baura, Kondoa
(Note the ritual hole at the centre) (Photo by author, 2001).

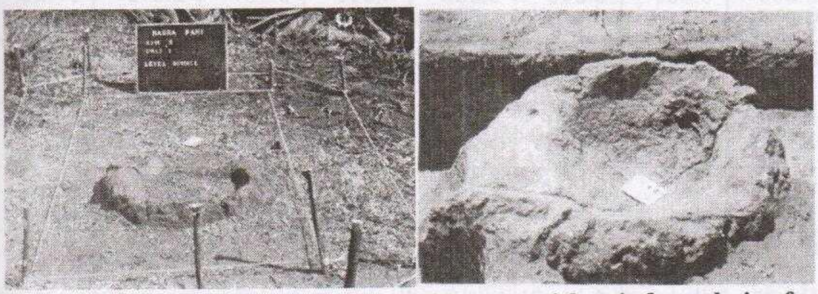

Plate 3: Concave-bottomed bowl furnace with reinforced rim from Baura, Kondoa
(On the left is before excavation, right is after excavation) (Photo by author, 2001)

While most recent piles of slag and tuyeres, some relatively intact, are located at the lowland where contemporary settlements are also found, highly weathered, thus, implicitly older remains are found along the mid-slope where also gully incisions are severe. Pieces of slag and tuyeres are sometimes found at the bottom of the gullies. These either got washed down by rain from the top of soil pedestals or fell when the pedestals (such as that on Plate 1), on top of which they were previously located, crumbled. Otherwise materials found at the top of the pedestals are often too fragmentary and undiagnostic.

One reason, and probably the most important one, that made Kondoa Irangi the centre for ironworking in Central Tanzania is easily available and abundant ore. According to oral sources, iron ore was obtained from two locations: Intela river valley, west of Lake Haubi, and Baura River valley in Baura. Located about five kilometres apart, the two sources produced sand ore, known locally as msimu, which the two rivers (which can correctly be termed as seasonal water courses) would wash downstream from amphibolite rocks dissected upstream. Elemental analysis conducted on the ore from Intela shows that this was a titanium-rich ore (Table 1 below), technically known as ilmenite ($FeTiO_3$).

Table 1: Elemental analysis[8] of sand ore and iron slag from Haubi, Kondoa (Quantity by weight percent (Wt %))

Element	Sand Ore					Slag		
	A	B	C	D	E	F	G	H
Fe	**48.621**	**31.055**	**34.402**	**53.247**	**21.236**	**63.634**	**58.192**	**62.288**
Si	0.000	0.000	0.000	0.000	8.601	3.389	2.875	3.626
Ca	0.000	0.000	0.000	0.000	0.176	2.659	0.649	2.849
P	0.000	0.026	0.000	0.000	0.822	0.061	0.011	0.048
Al	0.000	0.101	0.000	0.000	1.738	2.002	5.950	0.894
Mg	0.037	0.000	0.000	0.000	0.043	0.137	0.618	0.231

[8] The analysis was conducted by the author in 2000 at the Institute of Archaeology, UCL using a Superprobe JXA-8600. Columns A-E each represents a single probe taken on separate sand particles but all from Intela ore source. Columns F-H each represents a separate slag from different sites at Haubi: F (site No. 22); G from Matei's home); and H (site 6). For samples from other regions in Tanzania see Mapunda (2002b).

Mn	0.294	0.234	0.550	0.196	0.164	0.228	0.253	0.135
S	0.000	0.000	0.000	0.000	0.031	0.012	0.000	0.000
Na	0.000	0.000	0.000	0.000	0.046	0.082	0.025	0.021
K	0.000	0.000	0.000	0.000	0.622	0.372	0.000	0.000
Co	0.058	0.038	0.042	0.052	0.026	0.067	0.060	0.069
Ni	0.000	0.013	0.000	0.000	0.004	0.011	0.002	0.006
Cu	0.000	0.001	0.000	0.000	0.001	0.010	0.010	0.009
Ag	0.001	0.000	0.000	0.008	0.024	0.006	0.000	0.000
Ti	**12.363**	**31.661**	**28.296**	**10.606**	**10.411**	**2.798**	**2.750**	**4.092**
Pb	0.054	0.008	0.063	0.074	0.047	0.094	0.093	0.052
As	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.059

Both written (Liesegang, 1975; Kjekshus, 1996) and oral sources (Shaaban Kideso, informant, 1998) show that ore was collected and sorted through winnowing by women who then sold it to smelters, usually on credit, to be paid later by means of the product of the given ore such as hoes, knives, or raw iron (bloom). Although the antiquity of the involvement of women in ore collection cannot be ascertained, there is no reason to suggest that it is a recent practice. Evidently, the Rangi women were not unique in this practice. This was also the practice among Pare women of Northern Tanzania where smelters used sand-ore (Mapunda, 2002a) and from south-western Uganda, where women were involved in the entire process of iron production, including ore collection and preparation (Nyiracyiza, 2013).

So far no archaeological evidence of ore quarrying has been found in Kondoa Irangi. This is not surprising because ore of this type appeared in form of river deposits which would be collected during the dry season. The deposit would hardly exceed ten centimeters in depth, therefore difficult to be noticed. In addition, replacements and refills of the pits would occur every rainy season. Furthermore, oral accounts deny knowledge of ore quarrying – a practice that could have triggered or exacerbated gully erosion

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4.0 The link between ironworking and deforestation: A discussion

We need to bear in mind from the outset that the rate of charcoal consumption in pre-industrial iron smelting was a function of its quality in terms of caloric power in relation to furnace size and time (duration of smelt). Large furnaces such as those used by the Tumbuka, Nyiha, and Fipa in Lakes Nyasa-Tanganyika corridor, South-Central Africa, which measured between 250-350 cm high by 150-200 cm in diameter (Plate 4) consumed about 1,450 kg of charcoal per smelt that lasted for 114 hours, including 24 hours of ore roasting (Killick 1991:63-4). The Rangi smelters on the other hand, used small, bowl-shaped furnaces measuring at most, 50 x 50 cm in depth and diameter (Plates 2 & 3). According to oral accounts, one smelt, which lasted between 4-6 hours, consumed about three gunny sacks of charcoal, that is, about 75 kg. If we are to use Peter Schmidt's (1997a:68)[9] ratios, this would mean 750 kg of wet wood, which is equivalent to one medium-size tree.

One should note that although when calculated per smelt the bigger furnaces are found to have consumed almost 19 times more charcoal than the small bowl-shaped furnaces, the two technological variants consumed almost the same amount of charcoal when calculated in terms of time. This is because within the 114 hours the tall furnace would be in operation, the smelters of the small furnace could conduct about 19 smelts (114 hours divided by 6 hours, which gives us 19); and when multiplied by 75 kg of charcoal per smelt, it comes to 1,425 kg (i.e. only 25 kg short of the estimation for the tall furnaces).

[9] During his iron-smelting experiments conducted in Western Lake Victoria, Tanzania, Peter Schmidt weighed the wet wood prior to burning it for charcoal. He later weighed the resultant charcoal and found that it weighed 10% of the wet wood weight.

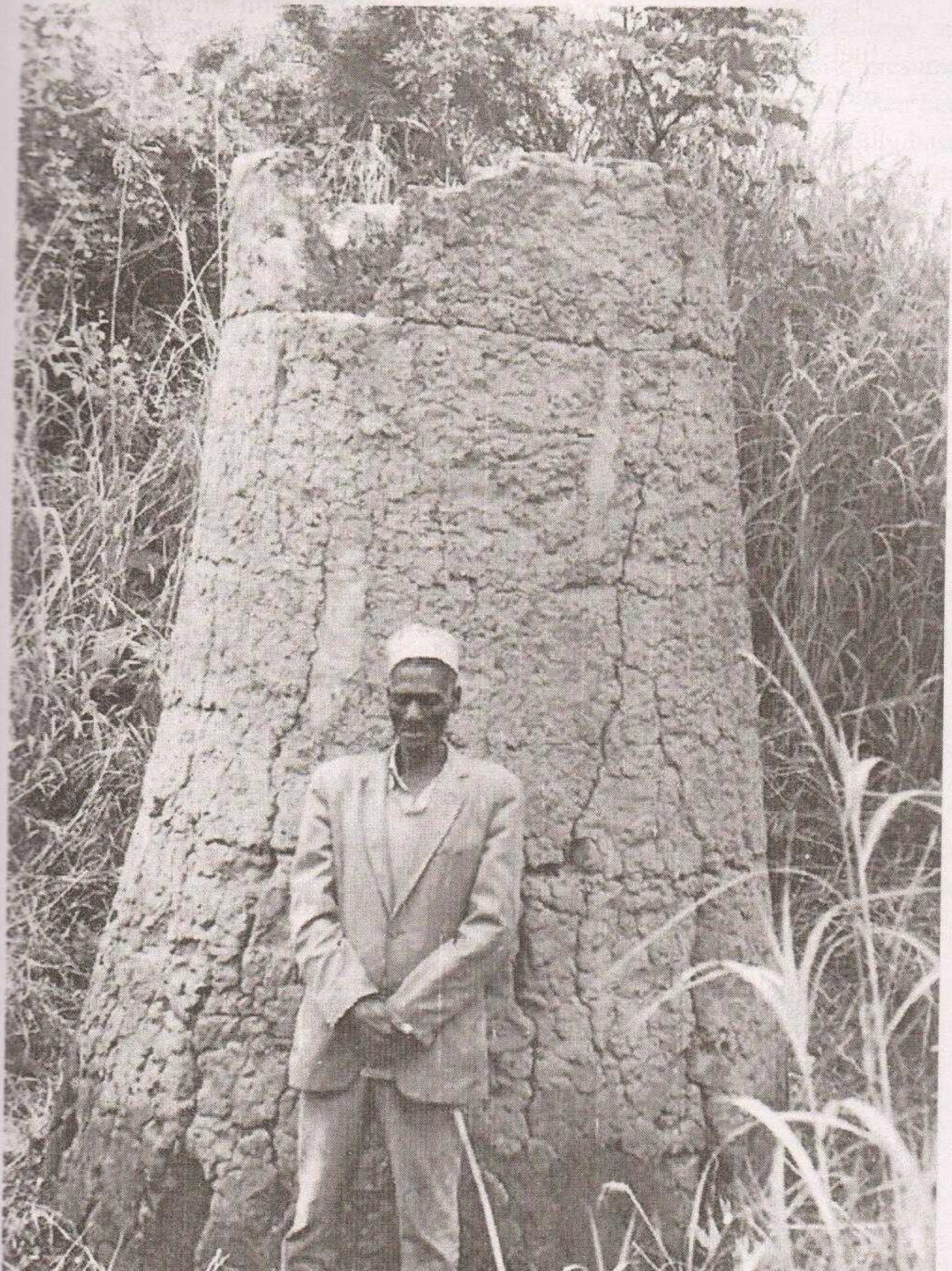

Plate 4: A Fipa, tall furnace
(Photo by Author, 1993)

The analysis given above leaves no doubt that iron smelting was fuel-intensive. In fact this was true for the production of other metals and alloys as well, including copper, bronze and brass. It is for this reason therefore that metallurgy has, throughout history, been associated with deforestation (Fyfe *et al.*, 2013). For example, discussing about the Bronze Age (over 4.5 millennia ago) of Eastern Europe Stuart Piggott writes:

> In Hungary, Rumania, and Slovakia it seems as though individual schools of copper metallurgy were operating before 2500 B.C., … Among their most characteristic products were massive shaft-hole axes, a type probably of Anatolian ancestry; in later phases we have also axe-adzes, both suggesting large-scale tree-felling and woodworking" (Piggott, 1968:107-108).

The Weald of Kent in England is another most cited metallurgical site in Europe which has dominated discussion. among environmental archaeologists and historians on the subject in question (Straker, 1931). The discussions started with rational concerns, but later the matter became highly politicised and even scientific arguments were no longer honoured, as Richard Cowen notes:

> In 1558, the first year of Elizabeth's reign, the government passed a law forbidding the felling of trees to make charcoal for iron smelting, but again political and economic pressures forced the exemption of the Wealden charcoal-makers from that law. … By this time the law could pass without effect on the strategic production of cannon in the Weald, because coppicing rather than tree-felling supplied almost all of the charcoal" (Cowen, 2013:8)

Blindfolded by political and economic motives and influenced by Eurocentric worldview, colonial masters as well as scholars transported European experiences to Africa verbatim. They propagated that indigenous ironworking was a potential cause for deforestation, and for that reason it had to be stopped. However, they failed to note one pertinent difference between forests in Europe and those in tropical Africa. The former are largely homogeneous whereas the latter are by and large heterogeneous. In other words, temperate forests such as those of Europe grow in stands of homogeneous species while those in the tropics grow as mosaics of multiple species. This difference is important to bear in mind for various reasons. Barbara Eichhorn, writing about the relationship between iron metallurgy and deforestation in Dogonland, Mali, says: "In anthropological literature, presumed severe ecological consequences of West African iron metallurgy have often been put forward. … The assumption of environmental degradation was mainly based on estimates of wood consumption" (Eichhorn, 2012:142). She concludes that this approach is wrong as "wood is a regenerative resource and its use may be sustainable as long it does not exceed the production rate" (*ibid*). Similarly, Eichhorn *et al*. argue that savannahs are reproductive systems and even fields and fallows in traditional agro-forestry systems reproduce a considerable amount of wood (Eichhorn *et al*., 2013).

Furthermore, most metal workers across the globe were species-selective when it came to vegetal resources such as charcoal or techno-medicinal (ritual) ingredients (Mapunda, 2013b; Lyaya, 2013). It therefore follows that an iron smelter from England for example, who used Oak for charcoal, could more easily cause deforestation because that one species could constitute the entire population of trees in a given area of land. But that would not be true for a counterpart in Tanzania who used for example the African ebony for the same purpose. The latter is likely to cause a localised extinction of the species in question without causing deforestation because the selected species would grow in a mixture of hundreds or thousands of other species in any given forest (Kikula, 1979).

When such selective exhaustion occurred, smelters relocated to a new area where the species in question would be available, as Peter Schmidt notes from West Lake Victoria:

> By the beginning of the present century [20th], in most areas fuel was thus a much more highly restricted commodity than was iron ore. Iron smelters in the northern part of the region, particularly in Kiziba, were forced to relocate to the south near Lake Ikimba because of the depletion of forests in their home area.... Direct historical testimony from these ironworkers indicates that they favored several species of trees and moved their smelting locations periodically to save labour costs in fuel transportation. In other words, they followed the availability of certain forest resources in an environment completely remade by humans (Schmidt, 1997a:273).

What Schmidt reports here was not spatially specific to the West Lake Victoria Region but rather a typical characteristic of pre-colonial metallurgy in much of tropical Africa. Randi Haaland observed a similar phenomenon in Dafur, South Sudan, in the 1970s where only two tree species were exploited: *Acacia nilotica* and *Tamarindus indicus*. This is what he said:

> In Toumra [a village in Dafur] the blacksmiths nowadays [1978] have to walk for two days to get the wood needed for iron forging, while 25 years ago they claim that these trees were growing around the village. … According to my main informant the village consisted 25 years ago of 25 huts for iron working and 150 families. In 1978 during my fieldwork the village consisted of 4 huts for iron working and 25 families. The people are moving south to the area around Kebkabia (Haaland, 1985:63).

It should be noted that migratory solution was possible by then because the population was still small and landownership was based on utility – one owned land as long as one was using it. This allowed people to move freely and occupy new lands at will. Migration in pursuit for metallurgical resources also accounted for the emergence of mobile ironworkers such as Rongo of North-Western Tanzania and Chisi of Northern Mozambique. These ironworkers who were both smelters and black smiths did not have permanent locations, but moved from place to place in search for suitable resources (rightful wood for charcoal and quality ore), as well as markets for their end products (Mapunda, 2010).

Non-species selection, which Schmidt calls "omnivorous wood consumption", was not a common practice in tropical Africa; but even where this form of wood consumption was practiced, as was the case among the Fiko and Kema of Mali, evidence shows that a degree of selectivity of some kind was exercised as Eichhorn *et al.* note:

> The final wood choice for the production of charcoal in the bloomery furnace was not completely arbitrary. The charcoal assemblages of both Fiko and Kema are in all samples dominated by trees and shrubs with dense woods … which guarantee a high burning value. Light-wooded species are hardly represented, although quite common in the savannahs and agro-forestry parks of the area (Eichhorn *et al.*, 2013:439).

We also learn of omnivorous wood consumption from West Lake Victoria Region in Tanzania. This comes from two archaeological sites, KM 2 and KM 3 which date to 2,500-2,000 BP. At the former, Schmidt notes 16 species to be used while at the latter 12 (Schmidt 1997a). He suspects that the iron smelters here collected readily available wood, but again "much of it of high quality", that would have been left lying about near new farm plots prepared for swidden agriculture (Schmidt, 1997a: 274).

All in all, to prove that omnivorous wood consumption was an unusual phenomenon in the region, the practice was evidently abandoned at KM3 site around the fourth century AD when "only two moist-forest species were used" while at KM2 site "only three species were presented" (Schmidt, 1997a). This continued to be the case until the beginning of the 20th Century A.D. when iron smelting reached termination in the area (Schmidt, 1997a, b).

Ironworkers of Kondoa were species-selective. Local informants have named a total of seven species ironworkers choose from. These included Kihungawisu (*Acacia nilotica*), Msakasaka (*Rhus natalensis*), Muthigiri (*Acacia millifora*), Saimo (*Acacia xanthophloea*), Mgunga (*Acacia hockii*), and Mlama (*Terminalia sp.*) – for smelting; while Msisiviri *(Albizi amara)* was used for blacksmithing. Furthermore, smelters used to have personal preferences, usually confined to only two or three species (Shaaban Kideso, informant, 1998).

Being species-selective, iron smelters in Kondoa Irangi could not have caused forest depletion. In fact, both oral sources and archaeological evidence show that charcoal used for iron smelting came from large trees, which indicates that by the early twentieth century even the selected species were not yet depleted. All this leads to the conclusion that the linkage between ironworking and deforestation, generally extrapolated, is an oversimplification; the situation on the ground is more complex than is generally assumed. In sum, ironworking in tropical Africa had no direct causative relation with deforestation. It does not however follow that ironworkers who were practicing species selection in the tropical region could be completely exonerated from deforestation; they could be taken indirectly responsible. Their main liability was supplying farm implements – hoes, axes and billhooks – with which farmers, particularly those practicing swidden farming, used to clear forests much faster than using lithic, wooden, or bone implements, as used before the coming of iron.

In Tropical Africa, swidden farming, based on the production of grains, especially sorghum and finger millet, was coincidentally expanding alongside iron technology (Ehret, 1998, 2002). Unfortunately, relics of iron technology especially slag, tuyeres and furnaces preserve better and longer than agriculture-related materials such as seeds, grains, or even 'agro-landscape' such as ridges and terraces. This probably accounts for the confusion. The ubiquity of metallurgical remains in the archaeological record easily leads one to the conclusion that metallurgy was responsible for deforestation when it might not have been a direct factor. This is worsened by methodological limitations. For example, flotation is only casually performed in much of Tropical Africa (Reid & Young, 2000).

Reportedly, grain agriculture was introduced to Central Tanzania early in the second millennium A.D. (Iliffe, 1995:105). It would be noted that this was about the time when soil scientists recorded the beginning of the recent accelerated soil erosion in Kondoa (Eriksson, 1998). Eriksson also attributes the initiation of the recent accelerated erosion to intensification of human land use. Following on what Liesgang and Lane noted in terms of the timing of settlement in the Haubi area, and following the fact that ironworking was not evident in the area until the early second millennium A.D., it is very likely that the earliest intensive land use activities in the area involved swidden farming and perhaps livestock keeping.

Although no conclusive research has been undertaken in Kondoa Irangi regarding the causative relationship between agriculture and soil erosion (see e.g. Mung'ong'o, 1990, 1999), several scholars have pointed out that intensification of farming in semi-arid lands may lead to severe soil erosion (Kusimba, 2004; Håkansson, 2004; John, 2011). These scholars variably attribute intensification of soil erosion during the nineteenth century to the intensification of agriculture which by and large was caused by the expansion of caravan trade in ivory and slaves in Eastern Africa. Thomas John, for example, notes that trade in ivory triggered agro-pastoralists and pastoralists to live in areas with very low rainfall, which were unsuitable environments for cultivation but suited to the herding of cattle. Consequently, "this would have created damage in some dry and erosion-sensitive environments such as the area around Lake Baringo, Kenya" (John, 2011:74).

The climatic condition of the region around Lake Baringo in Northern Kenya is very similar to that of Lake Haubi, in Kondoa Irangi. Very likely, similar factors operated in Kondoa especially taking into account that Kondoa was one of the outstanding trading stations in the interior of Tanganyika during the nineteenth century (Iliffe, 1979; Christiansson, 1981; Östberg, 1986). Similarly, Håkansson and Widgren note that "the most heavily travelled caravan route passed through some of the most inhospitable environments in Tanzania, Ugogo and Kondoa" (Håkansson & Widgren, 2007:239). They further elaborate that:

> At one end of the spectrum of land use are Kondoa and Ugogo, where expansive agriculture and grazing caused soil erosion to such an extent that, in 1973 (Kondoa) and again in 1986 (Ugogo), the Tanzanian government deemed it necessary to enforce strict regulations on land use and evicted all cattle in order to allow regrowth of vegetation" (Håkansson & Widgren, 2007:234).

Emanuel Kessy also argues that expansion of agriculture very likely "resulted in extensive land clearance to increase agricultural production, an activity which ultimately accelerated land degradation" (Kessy, 2005:10). As opposed to ironworking which has left conspicuous evidence in Kondoa Irangi such as slag, tuyere fragments and furnaces, tangible evidence for swidden agriculture is hard to find archaeologically. We, however, note from ethnography, the application of swidden agriculture, with finger millet as the main crop, being a common practice in Kondoa Irangi today (Plate 5).

As regards livestock keeping, we also note analogous conditions in recent years. Similar to agriculture, livestock keeping has proven to have a direct degenerative impact on the vegetation cover. In the 1970s, for example, the government banned open-air grazing, and introduced zero-grazing in places with severe soil erosion such as Haubi. Evidently, this measure led to a major improvement of vegetation regeneration and gully recovery (Lane 2009), showing a clear causative relationship between conventional livestock keeping and soil erosion.

In short, had iron technology been the direct factor for deforestation and subsequently soil erosion, we would have expected to witness major improvements on soil erosion since the beginning of the twentieth century when iron smelting ceased to operate in Kondoa Irangi. Apparently such correlation is non-existent. To the contrary, both soil erosion and forest depletion has intensified progressively since the beginning of the 20th century (Erickson, 1998). Doubtlessly, the cessation of indigenous production of iron paved the way for imported iron, the supply of which was more abundant than the previous locally produced type. This raises an important research question as to whether or not the imported metal implements were a factor for the intensification of soil erosion during the colonial time, especially in relation to swidden agriculture (Plate 5).

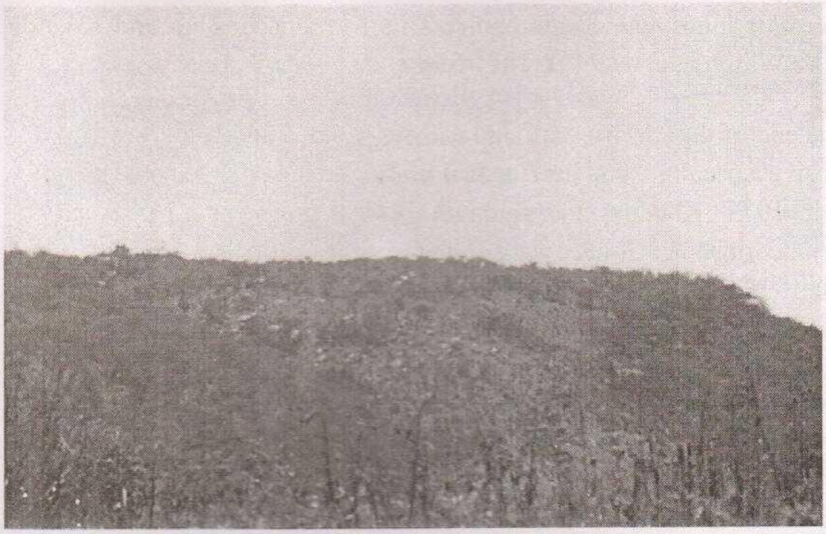

Plate 5: Land cleared for swidden agriculture on Intela Hill, west of Haubi Lake
(Photo by author, 2001)

5.0 Conclusion

In this article, the impact of indigenous iron production on the environment in general, and forest and soil erosion in particular, has been examined. Using data from Kondoa Irangi, Central Tanzania and other areas around the globe it has been concluded that indigenous iron technology in Kondoa, as in some other regions in Tropical Africa, did not directly cause deforestation. This is because iron smelters in Kondoa were species-selective; picking up to three species of trees for charcoal, and leaving the other hundreds of species intact. This practice had varied environmental impact between tropical and temperate regions. In the former, it affected the selected species and not the entire forest population. This is because the profile of woody vegetation in any given area tends to be heterogeneous, a mixture of dense and light wood, allowing the 'unfavorable' species to continue growing as the 'less unfavourable' ones get consumed. As an adaptive mechanism, after exhaustion of the selected species, metal workers relocated to other areas where favourable species were available. In so doing, exhausted species in the former settlement got a chance to sprout and/or regenerate, even though the process could take decades or even centuries.

The situation would be different in temperate zones, where trees grow in stands. There, species selection for metallurgy could more likely cause deforestation and species extinction because choosing a species could easily mean clearing the entire forest as that could be the main woody species in the forest. Unfortunately, this scientific truth of the temperate zone was erroneously imported wholesale to Tropical Africa by both colonial masters and Eurocentric scientists. In this article, with evidence and examples, it has been possible to expose and refute this fallacy. What Cowen remarks on the Weald of Kent is true also for Kondoa and perhaps many other places in Tropical Africa: "…the iron industry has been unfairly blamed for the deforestation of the Weald. Deforestation was not confined to the Weald: whatever caused it was more than iron-working, … However, the accusation of deforestation was used as a powerful propaganda weapon against the iron-masters" (Cowen, 2013:8).

The factors for soil erosion in Kondoa Irangi are multiple and complex, ranging from natural such as alternating dry and wet climate and low soil compactness to human influence such as swidden agriculture and livestock keeping. Ironworking played only an indirect role and much later in the long history of almost 15,000 years of erosion in the area.

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