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Local blacksmiths's activity in the west region of Cameroon and their contribution to the development of micro hydroelectric power plants in that region

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As a result of the nature of pollutant and exhaustible of fossils energies, developed countries have made use of renewable energy sources to make effective their energy systems. To stow on that vision in Cameroon, the promotion of micro-hydroelectric powers plants (MHPP) is a priority and any contribution to its ease is beneficial. The objective of this study is to characterize some main forges in the west region of Cameroon and show their technical input in the development of MHPP in that region. The survey was conducted in January, 2014. Socioeconomic data related to blacksmiths and main features were studied by the use of questionnaires, direct interviews, site observations and measurements. Main results show that the first forges was set in the Foto village in 1850 by blacksmiths from Nigeria. The studied forges are of traditional (62.5%) and modern type (37.5%). More than 50 products belonging to the main use sectors are manufactured, adapted and/or repaired. The main problems identified are acquisition of raw materials, the lack of equipment and limited technical knowledge. The blacksmiths has been involved in MHPP facilities since 1997, the installation year of the pilot MHPP with the participation of local craftsmen. Civil engineering structures, hydroelectric unit, transportation and distribution equipment are built by local blacksmiths using as much maximum materials as possible. This is often a source of malfunction. Thus, funding of local craftsman and equipment by the government or other agencies can render the forges useful for sustainable development in the west region of Cameroon.

Key words: Study, blacksmiths, micro hydroelectricity, funding, Cameroon.

INTRODUCTION

All developed countries have made use of renewable energy sources to make effective their energy systems. Energy from micro-hydroelectric powers plants (MHPP) has been an important component of renewable energy for countries which have the potential. For Cameroon to carry out this vision, the promotion of MHPP is a priority

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and any contributions to its ease are beneficial.

The access to electricity in Cameroon was about 49% in 2012. But this rate is about 23% in rural areas (Lighting Africa, 2012). In many of these areas, there are streams which flow; sufficient development could be interesting alternatives for the production of electricity from MHPP. Several sites favorable for MHPP have been identified, particularly in the Western Region, where without being exhaustive, about 35 sites have already been identified and characterized and fewer than 5 are in operation. The use of MHPP with a power of 153 kW started in 1997 with pilot project funded by World Bank in Bamougoum village. The first MHPP was set up in west region in part by the important contribution of local blacksmiths. Especially for the manufacture and supply of components such as turbines, water wheels, penstocks and many others mechanical accessories. But the activity of the local blacksmith remained much neglected despite its potential to promote development of production activities. Note, however, that so far in many developed countries, craftsmen make a significant contribution to the design, manufacture and repair of equipment and many tools used in rural and in urban areas. In Cameroon, despite their importance, few studies have so far been devoted to a better knowledge of craftsmen to consider improving their technical knowledge and facilities.

The objective of the present study was to characterize some main forges in the west region of Cameroon and show their technical input in the development of production activities generally and particularly MHPP in that region. This is in preparation for the improvement of blacksmiths skill and MHPP development.

The survey took place in the Foto village. It is situated in the west region of Cameroon and geographical coordinates are: 5° 27' 0" North, 10° 4' 0" East. The altitude varies between 1200 (Bamoun plateau) and 2740 m (Bamboutos Mount) with an average of 1500 m. The mountainous relief and the rainfall (1600 to 2000 mm) are suitable to hydroelectricity (Helvetas, 1981). The population is about 1.8 million inhabitants with a yearly growth rate of 2.8%. The average density is 128.5 inhabitants/km^2. The main economic activities are agriculture, livestock breeding, some industrial units of transformation (soap factories and brewery), forges and the commercial exchanges with the other regions.

MATERIALS AND METHODS

Description of MHPP

MHPP is a type of hydroelectric power that typically produces up to 500 kW of electricity using the natural flow of water. MHPP is frequently accomplished with a Pelton wheel for high head, low flow water supply. The installation is often just a small dammed pool, at the top of a waterfall, with several hundred feet of pipe leading to small generator housing (Gagliano et al., 2014; David, 2013). The intake then tunnels water through a pipeline (penstock) to the powerhouse building containing a turbine. The turbine turns a generator, which is then connected to electrical loads; this might be directly connected to the power system of a single building in very small installations, or may be connected to a community distribution system for several homes or buildings (Ramos et al., 2000). Usually, MHPP installations do not have a dam and reservoir. There is a lot of main mechanical component used for building and/or maintenance of the hydropower (turbine, trash rack, boxes, eyebolts, lampshades and screwdrivers).

Power from such a system can be calculated by the equation P=Q*H/k, where Q is the flow rate in gallons per minute, H is the head loss and k is a constant of 5,310 gal*ft./min*kW.

Potentiality for MHPP in Cameroon

In electricity, Cameroon has the second hydroelectric potential in sub-Saharan Africa (19.7 GW fairly technical potential for an energy production of 115 TWh/year). Now, less than 5% are operated. In view to promote the renewable energy in Cameroon, almost 200 sites for MHPP have been identified by ARSEL (the company for regulation of electricity sector), of which 35 were more precisely identified and characterized in the west region (Adam and Associates, 1997; TEKOUNEGNING, 2011).

Methods

This survey was conducted in January 2014. Socioeconomic data related to blacksmiths and main featured were studied by the use of questionnaires, direct interviews and site observations. Workspace dimensions were measured using a tape. During this study, data related to the products were manufactured for main sectors of activities and for development of the MHPP in the region collected. These data concerns history (origin and creation date of forges); socioeconomic features of blacksmiths (sex, age, education level, major activities and forge organization) and forge techniques (equipment, raw materials, manufacturing processes and manufactured products).

RESULTS

Background

Origin

The initial forge (forge mother) was started in Foto village around 1850 by a family of immigrants from West Africa, probably from Nigeria. It appeared that it was first installed in the nearby village: Bafou, in Beng quarter before abandoning this locality to settle in Balefang quarter, in Foto village. Another part of this family left to create another forge in another neighbouring village of Foto, Fongo-Tongo, in Balefang quarter.

Dates of creation and kinship between forges of Foto

The dates of the creation and the kinship between the forges of Foto are indicate in Table 1. It shows that apart from two recent forges, all forges of Foto descended from the same mother, which confirms the strong family tradition of forges. Since 1995, there have been no more new forge in Foto.

Table 1. Dates of creation and kinship between forges of Foto.

Forges	Kinship	Date of creation
I	Mother	1850
II	Sister	1860
III	Sister	1900
IV	Sister	1950
V	Sister	1987
VI	Sister	1989
VII	Independent	1993
VIII	Independent	1993

Table 2. Distribution of number of blacksmiths by forge.

Forges	I	II	III	IV	V	VI	VII	VIII	Total
Number of blacksmiths	45	50	35	26	12	09	08	08	193

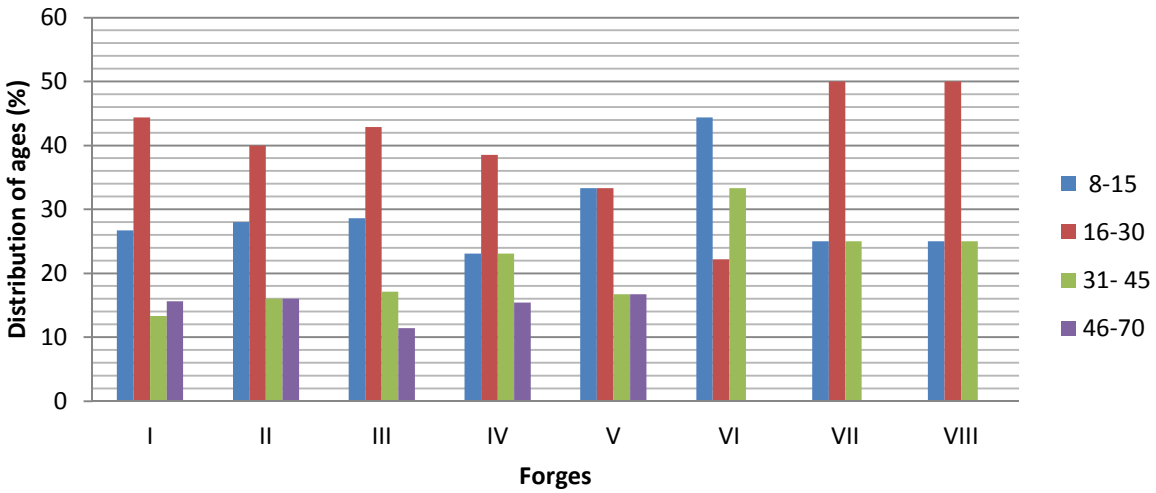


Figure 1. Distribution of blacksmiths by forge and age group.

Socio-economic features of blacksmiths

The socio-economic features of blacksmiths are indicated in Table 2, Figures 1 and 2.

Number of blacksmiths

The number of blacksmiths working per forge varies from 2 to 50 with an average of 24 per forge. About 50% of blacksmiths work temporarily, they are pupil and employees of others sectors. Forges VI, VII and VIII which are more modern possess the smallest number of blacksmiths, and have more efficient equipment. The distribution of number of blacksmiths by forge is summarized in Table 2.

Sex and age

According to the custom, blacksmiths are only men. Age of blacksmiths (Figure 1) varies from 8 to 70 years. These ages are classified in four group: [8-15], [16-30], [31-45] and [46-70]. Nearly 70% of blacksmiths are younger than 30 years since forging requires sustained physical effort. The forges VI, VII and VIII have youth for the sake of profitability. Theses forges have only 13% of blacksmiths but provide more than 95% of the global

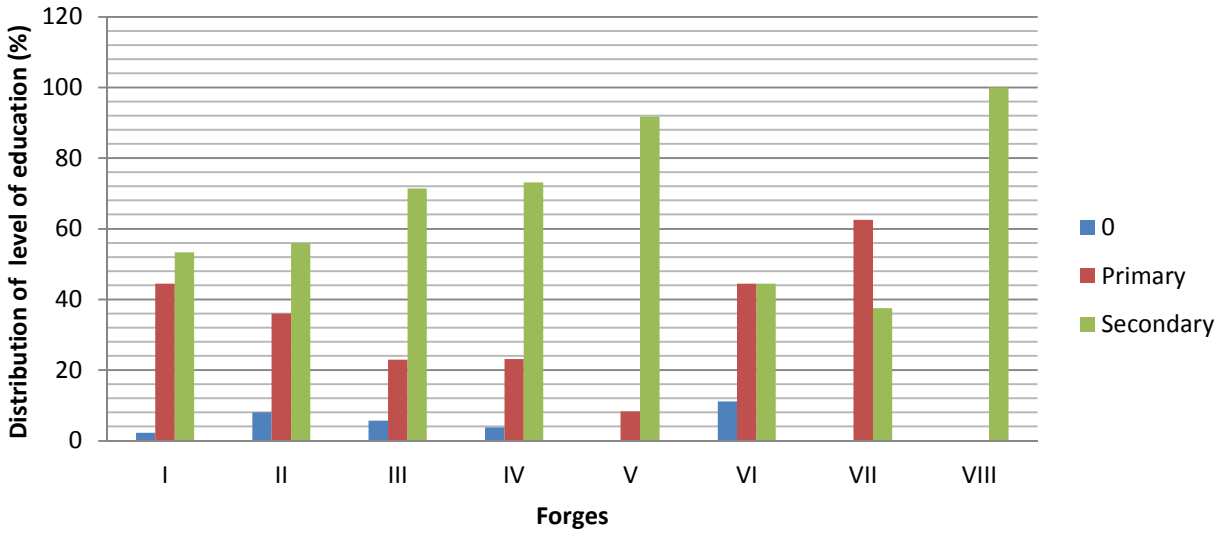


Figure 2. Distribution of blacksmiths by forge and level of education.

production of the forges. This is linked to the dynamism of the young, the productivity of modern equipment used and the organization of work which is the type boss-salaried employees.

Level of education

The distribution of blacksmiths according to the level of education and per forge is summarized in Figure 2. More than 95% of blacksmiths attended school with close to 62% of them having a secondary education. The high proposition of blacksmiths with secondary education is an asset in the context of training, extension and possible technical innovation adoption.

Main activities of blacksmiths

Of the blacksmiths interviewed, 56% them have the forge as the main activity, with agriculture (March-April) the second. The relatively high percentage of temporary blacksmiths is related to the proportion of young students engaged in the forge during school holidays. Other blacksmiths are temporary employees of the liberal sector, public sector or traders.

Techniques of forges

Forge equipment

Repartition of forge according to the type of equipment: Based on UNIDO (United Nations Industrial Organisation) technical standards (Starkey, 1997), one can classify the Foto forges in 2 categories according to the equipment used as shown in Table 3. This table indicates that 62.5% of forges fall in the category of so-called traditional forges. They are less efficient.

Workspaces and blacksmith equipment used: Traditional forges use simple hangars (Table 4) less than 3 m high and opened on all sides. Conversely, the modern forges are housed in real workshop spaces 3 to 4 greater than those traditional forges. The more spaces and comfort found in modern forges arise and are derived from the need to protect a greater number of facilities and also to secure the large volume of storage of raw material and end products. The basic equipment are the same in all forges, although more sophisticated ones are found in modern forges. It is important to note that protective equipment such as safety goggles, gloves and overalls are only in modern forges (CEEMAT, 1974).

Sources of raw materials

Table 5 gives the sources of raw materials for the different categories of forges. Traditional forges get their raw material from two main sources. On the contrary, modern forge materials are from hardware stores.

Manufacturing process

Table 6 summarizes the manufacturing operation. The tasks such as welding and painting are executed only in modern forges. Even if other operations are carried out everywhere, they are faster and more efficient in modern

Table 3. Repartition of forges according to the type of equipment utilized.

Forge categories	Type of equipment utilized	Forges	
		Number	% total
Traditional (I, II, III, IV, V)	Traditional	5	62.5
Modern (VI, VII, VIII)	Traditional and modern	3	37.5
Total		8	100.0

Table 4. Workspaces and blacksmith equipment.

	Forges / *Workspaces*	Area A(m^2)	Number	Total (%)
01	Hangar (traditional forge)	A<20	5	62.5
02	Workshop (modern forges)	A>80	3	37.5

Table 5. Sources of raw materials for the different categories of forges.

Categories of forges	Sources of major raw materials used by forges	
	Recycling materials	Hardware materials
Traditional	1 Car wrecks: bodywork, springs, engine part, chassis and tires 2. Saw blades, etc.	Metal sheets, concrete reinforcement steel, angle irons, galvanized pipes, etc.
Modern	0	Metal sheets, concrete reinforcement steel, angle irons, galvanized pipes, welding electrode, etc.

Table 6. Manufacturing operations and equipment used by blacksmiths.

Operation	Equipment or tools used
Heating	Firewood and manual or electric bellows
Cutting	Chisel and hammer, shears; grinder; hack saw
Bending	1. Stone, engine block and other metallic block as anvil 2. Mechanic or hydraulic press and vice
Modelling	Tree-trunk, metallic block, cylindrical iron bar, hammer, press and template
Drilling	Engine block holes; awl; hammer; electric drill; press drill
Riveting	6 or 8 mm iron bar, hammer or press
Welding [m]	Arc or welding
Smoothing and sharpening [m]	File or grinder
Painting [m]	Brushes and paint

m: Operations made only by modern forges.

forges because of their facilities. It is important to note the progressive inter-dependency between the forges; the traditional forges require modern forge services for tasks that their facilities do not permit them to execute (soldering, cutting, etc)

Main manufactured products

Main manufactured products in both types of forges: Table 7 gives the annual production of manufactured products in both types of forges. The hoe is the most manufactured tool. This is because it is highly utilized in all phases of the agricultural calendar and has a low life span. On the other hand, the trident, which is produced less, is manufactured using raw materials of a higher quality and is less frequently utilized. Regarding the MHPP facilities, the World Bank funded the construction of a pilot MHPP in Bamougoum village in 1997 with the participation of artisans (Adam and Associates, 1997). This has created a big impact in this village as it attracts

Table 7. Annual production of main manufactured products and MHPP equipment by categories of forges.

Manufactured tools or equipment	Annual production (number)		
	Traditional forges	Modern forges	Total
Agriculture tools			
Hoe	5 000	150 000	155 000
Jab planter	3 000	8 000	11 000
Axe	700	6 300	7 000
Dabba (tool used to dig)	1 000	4 000	5 000
Trident	160	2 200	2 360
Kitchen knife	4 000	0	4 000
Cooking pot	3 500	0	3 500
MHPP equipment			
Trash rack	0	30	30
Metallic pipe (2 m in length)	0	100	100
Pelton turbine	0	10	10
Cross flow turbine	0	4	4
Water wheel	0	2	2
Boxes	0	300	300
Eyebolts	0	3 000	3 000
Lampshades	0	1 500	1 500
Screwdrivers	0	200	200

development committees of other villages who seek to acquire the same skills in order to replicate that technology in their localities. The MHPP they set up supply electricity to homes and public places. The electricity is also used for other various activities such as food processing. One can expect improvement in the near future with blacksmiths training in the MHPP technology as there is no company in Cameroon making MHPP equipment (Tekounegning et al., 2008). One also notes that blacksmiths dealing with MHPP are from the same modern forge.

Time, period of manufacture and life span of the main manufactured products

The time, period of manufacture and life span of the main forged tools are shown in Table 8. The hoe, the most requested tools was made 30 times faster in the modern forges than in the traditional one. Apart from axes and tridents, the other tools are manufactured according to the agricultural calendar: so hoes are requested during periods of cultivating and weeding; the jab planter during planting, weeding and tuber harvesting period; and the “dabba” (tool to work soil surface) are made during land preparation. The life span of products varies from 1 to 20 years.

Price comparison of forged objects and industrially produced objects

Table 9 lists the forged objects, their sectors of use and sale price as compared to equivalent objects of industrial manufacture. The forges manufacture or repair a very wide range of tools used in various sectors of activities. The main sectors are agriculture and construction. The equivalent products industrially manufactured or imported cost 2 to 10 times higher than those from the forges. This is related to the quality, the functionality and the life of the items. The FCFA was choosen because it is the local currency used (1 Euro = 656 FCFA).

Some important items not manufactured by local industries

Table 10 shows some important items not manufactured by local industries. The forges usually manufacture and repair their equipment. MHPP equipments are not on the market (Adam and Associates, 1997). They are manufactured, on demand, only by one modern forge. Without the contribution of blacksmiths, the development of MHPP in the west region of Cameroon would not have been possible.

Some important photos of local products forged

Photos 1 and 2 show agriculture products, Photos 3 and 4 show turbines (MHPP products), Photos 5, 6 and 7 shows some operation and equipments of forge.

DISCUSSION

With a simple calculation based on data from Tables 7, 9 and 10, in considering the total annual production (Table

Table 8. Time, period of manufacture and life span of the main manufactured products and MHPP equipment.

Manufactured tools or equipment	Fabrication time (minutes)			Life span (years)
	Traditional forges	Modern forges	Period of fabrication	
Agriculture tools				
Hoe	60-120	2-4	Nov-April	1-2
Jab planter	60-180	40-60	Dec-March	1-3
Axe	360-480	40-60	All year	10-20
Dabba (tool used to dig)	120-240	50-60	Dec-Aug	10-20
Trident	480-600	30-40	All year	1-2
Kitchen knife	20-40	-	April-Aug	2-4
Cooking pot	150-200	-	All year	15-35
MHPP equipment				
Trash rack	-	120-240	Dry season	2-4
Metallic pipe (2 m in length)	-	120-240	Dry season	4-6
Pelton turbine	-	720-1020	Dry season	6-8
Cross flow turbine	-	720-960	Dry season	6-8
Water wheel	-	1020-1740	Dry season	4-8
Boxes	-	60-90	All season	4-10
Eyebolts	-	1-2	Dry season	15-30
Lampshades	-	20-40	Dry season	5-8
Screwdrivers	-	35-50	All year	15-25

Table 9. Main forged tools distributed according to the sector of use, their functions and price comparison in the local market.

Sector of use	Name	Functions	Compared unit price (FCFA)		
			Forge (C_1)	Industry(C_2)	$C_2 - C_1$
	Needle	Sew bag after bagging products	60	-*	-
	Crowbar	Unearth stones	5400	30000	+24 600
	Wedge	Split tree trunks	1800	3000	+1 200
	Knives	Work in the kitchen and table	200	1200	+1 000
	Raffia knife	Tap raffia wine	950	-	-
	Trident hoe	Weed, hoe, stir soil surface	2050	3700	+1 750
	Skimmer	Remove food from heated oil	375	600	+225
	pruning	Cut bananas leaves, pick fruit	480	-	-
	Sickle	Cut straw	480	-	-
	pitchfork	Return, load manure	2400	7200	+4 800
	scraper	Grate tuber or fruit	480	4320	+3 840
Agriculture	Axe	Fell, cut, split trees	4800	14500	+9 700
	Hoe	Plough, weed, stumble, dig	1800	3000	+1 200
	Machete	Cut, split	2000	4900	+2 900
	Mould	Give forms to pastry making	960	1920	+960
	shovel	Dig, collect the soil	2300	3700	+1 400
	Pickaxe	Pick, loose stony soil	2400	9600	+7 200
	Planter	Plant seeds, weed, unearth tubers	725	2200	+1 475
	Stove	Fry, warm foods	1450	6000	+4 550
	Rake	Clean, level soil	1000	2200	+1 200
	Flint	Make fire	600	-	-
	Probe	Check the quality of seed bagged	960	-	-
	Sieve	Sift foodstuffs	500	6000	+5 500

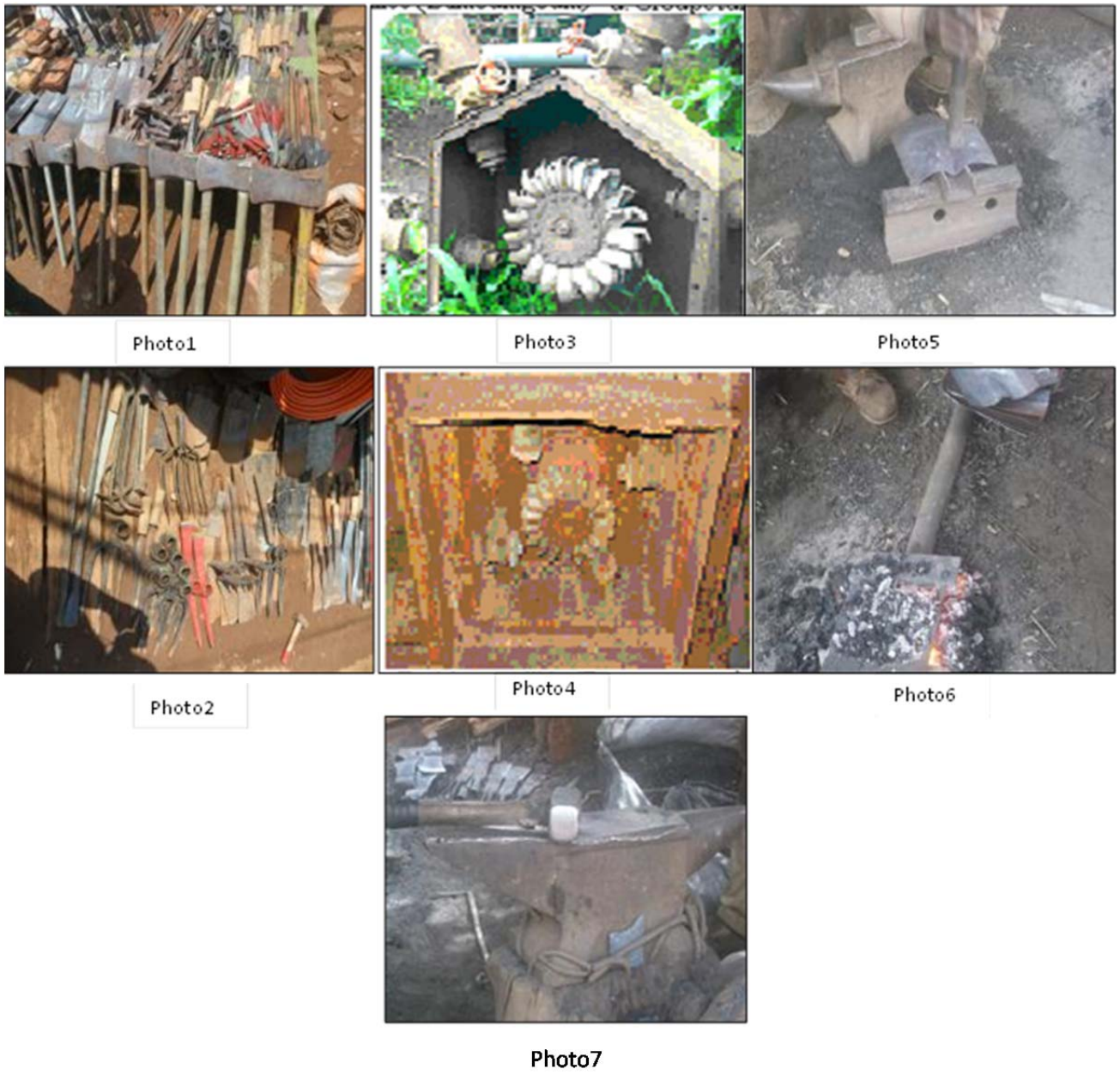
Table 9. Contd

	Trident	Break up, dig the soil, weed	4800	18600	+13 800
	Nail puller	Pull mails	2300	3700	+1 400
	Chisel	Cut sheet metal, break the concrete	840	5040	+4 200
	Shears	Cut metals	72000	108000	+36 000
	Art knife	Work bamboos	600	-	-
	Window	Ventilate and secure home	24 600/m^2	-	-
Construction	Scraper	Smooth wood	1200	-	-
	Saw	Saw wood	1800	3600	+1 800
	Hammer	Mail	1700	2200	500
	Hinges	Link post and door wing	1200	1920	+720
	doors	Allow user entrance, secure home	26 400/m^2	-	-
	Awl	Pierce sheet metal	850	1450	+600

*-: not found in local market.

Table 10. Some equipment of animal husbandry, hunting, war, socio-cultural rituals, forges and MHPP and their price on the local market.

Sector of use	Name	Functions	Price FCFA
Breeding, hunting, war	Iron hook	Stabilize attached animal	700
	Bell	Locate the dog during hunt	800
	Lance	Kill the game or the enemy	850
	Trap	Catch the game, mice	2 400
Socio-cultural rituals	Bracelets	Protect against evil spirits	250
	Bells	Rhythm dance	600
	Healer knife	Cure diseases caused by criminals	500
	Razor	Shave hair and beard	700
	Sabre	Perform warrior dances	900
Forge equipment	Anvil	Beat iron	-
	Vice	Tighten iron	-
	Millstone	Grind and refine forged items	-
	Shears	Cut metals	-
	Press	Pierce, give shapes to objects	-
	Bellows	Inflame fire	-
MHPP equipment	Trash rack	Prevent trash getting into conduits	1500 to 6000
	Metallic pipe (2 m in length)	Convey water under the pressure	8000 to 18000
	Pelton turbine	Transform energy of flowing water into mechanical rotary motion transferred to the generator	200000 to 800 000
	Cross flow turbine		140000 to 300 000
	Water wheel		300000 to 1100 000
	Boxes	Secure devices	1500 to 10000
	Eyebolts	Anchor cables on wooden poles	400 to 1000
	Lampshades	Protect outdoor lamps	1000 to 3000
	Screwdrivers	Tie or untie screws	500 to 2000



Photos 1 - 7. Some important products of forge.

7) and the unit prize of manufactured main products and MHPP equipment (Tables 9 and 10), an estimation of the turnover of the local workshops studied is about 750 000 000 FCFA (= 1 14 293 Euros). Manufactured items are used both in rural and urban areas. They are cheaper than industrial products but in general, their quality is poorer. The prices of these products correspond to the level of current income and purchasing power of people.

For the same reason, the MHPP can also have a good valorisation in the west region of Cameroon, with the contribution of these local products manufactured by forge.

Conclusion and recommendation

Main results show that the first forges was set in the Foto village towards 1850 by blacksmiths from Nigeria. The studied forges are of traditional (62.5%) and modern type (37.5%). More than 50 products belonging to the main use sectors are manufactured, adapted and/or repaired. Although, there are a few forges, about 193 person work there, and it is appreciable. They produce a wide range of tools for the different sectors of the population activities and at cost compatible with their purchasing power. These products are at least 40% cheaper than products

from industries. The value of production is unrelated to investment but is usually high for rural areas.

Actually, the State of Cameroon promotes renewable energies, of which MHPP is an essential component (Law No. 2011/022 on 14th December 2011 governing electricity sector in Cameroon). The contribution of local blacksmiths is very interesting to boost MHPP in Cameroon, with regards to the west region. Local forges have a lot of potential in the production of MHPP components in general and particularly the turbines and water wheels, penstocks and many other mechanical accessories.

More than 95% of blacksmiths attended school with close to 62% of them having a secondary education. The high proposition of blacksmiths with secondary education is an asset in the context of training, extension and possible technical innovation adoption. The areas for improvement should also focus on better organization of forges, equipment and training of blacksmiths. This is left government and non-governmental organizations.

Conflict of interests

The authors did not declare any conflict of interest.

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