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INNOVATION TECHNOLOGIES AND BIOMASS PROCESSING TO FACILITATE THE ENERGY ACCESS IN RURAL COMMUNITIES. ANALYSIS OF KENYAN MUNICIPALITIES

by

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1. Introduction

The traditional concept of development concerns the human actions that have modified the environment to create a space in which live adequately according to his needs. This development paradigm has begun to waver namely for the negative implications and damages for the environment and for the ecosystem, such as serious phenomena of global pollution and scarcity of resources available for future generations (Fischer et al., 2008). The result is a more awareness on the importance of a correct management of natural resources and a review of production and consumption patterns, elements that represent the starting point for a correct economic and social development. In the last decades, human activities have led to negative output in many areas, for instance irrational use of renewable and non-renewable resources, climatic alterations, imbalances in natural ecosystems, air pollution, soil and water resources caused by chemical agents and organic residues. The consequences of these actions are harmful for different subjects, not only human beings but also environment and ecosystems. The negative effects of this economic model affect indifferently developed and developing countries. If we focus our attention on developing countries, we note that despite being very rich in natural resources (Benghida, 2017) and depending on these resources for the internal economy and growth, at local level, multiple environmental and social problems are registered. In fact, the irrational use of natural resources determines an environmental degradation (Lewis et al., 1999) that frequently involves an intertwining of other factors of underdevelopment such as poverty, rapid demographic growth, and social inequalities. An accelerated development not suitable and unsustainable causes itself a rapid degradation of the environment and the dramatic destruction of the same natural resources with negative consequences both for the well-being and for the health of the population (Zhang et al., 2014).

At the end of the Second World War, industrial development was rapid and overwhelming, but also full of imbalances and limits. Innovation of technology and processes have been fundamental for the process of development and growth, heading the maximum level never registered before (Leaning, 1993). From the other side, the investment on fields and agriculture registered a decrease and the abandonment of countryside lead to phenomena of urban drift with consequences of

underdevelopment and concentration of population in urban neighbourhood. The imbalances pilot to significant increase in private consumption, with consequent stagnation in public consumption; imbalance between the progress of some sectors or economic activities with respect to the congenital backwardness in others; inability to bridge the gap between North and South.

In the 1960s started to be manifested the first cases of pollution, deriving precisely from the huge and unruly technological progress. The spread and blind confidence that market and growth were limitless allowed to conduct investments without taking into account any environmental aspect and the unlimited exploitation of natural resources was normally accepted as a price to be paid to nourish economic development and provide employment (Dempsey, 2011). At this time of the history, environment had only an instrumental value and exploitation of natural resources was conducted without limits. With the emergence of the first economic crises linked to the problems of scarcity of natural resources, confidence in unlimited growth began to be unreal and defined the first political crisis at international levels.

Almost immediately, was realized from international community that a common policy was needed for a new model of development to reconcile economic growth and fair distribution of resources. This new philosophy of conceiving the economy has begun to take hold since the end of the sixties thanks to the initiative of international conferences on the topic of development, linked to reduce and consider the natural systems to collapse. Economic growth in itself is not enough to create development: development is real only if it improves the quality of life in a lasting way.

2. Sustainable Development path

In 1972 the concept of Sustainable Development (SD) was introduced for the first time at the "*United Nations* (UN) *Conference on the Human Environment*" held in Stockholm. The term was not effectively defined, but the international community agreed to the theory that environment and development have to follow the same path, addressed as a unique topic, managed in a comprehensive perspective. SD was the solution to the problems of environmental degradation discussed by

the Brundtland Commission in the 1987 report "Our Common Future", were the parties investigated in the negative impacts on the planet in the previous decades related to despotic growth and unsustainable progress (Mitcham, 1995).

After the Stockholm conference, in 1980 was published the "*World Conservation Strategy*", the first international document on living resource conservation produced with inputs from governments, non-governmental organizations, and other experts. The document was prepared by the *International Union for Conservation of Nature* and Natural Resources (IUCN), reiterating the objectives of maintaining essential ecological processes, preserving the genetic diversity of biological organisms and sustainable use of ecosystems (Mebratu, 1998).

The term SD was spread only in 1989 in "*Our Common Future*", the report of the World Commission on Environment and Development, were the notion of SD was created and written: "*development which meets the needs of the present without compromising the ability of future generations to meet their own needs*". However, only at the Rio Summit the major world leaders recognised SD as the major challenge it remains today.

In fact the notion of SD has been defined in 1992, during the "*UN Conference on Environment and Development*" held in Rio de Janeiro, where for the first time Heads of State, representatives from 178 national government, representatives from non-governmental organisations and civil society were discussing possible framework for define strategies to reduce environmental degradation (Mebratu, 1998). The summit is known as the first international effort to move forward a different economic system, creating action plans and strategies for shared and common objectives. In the conference was written the "*Rio Charter*" with the values of the previous Stockholm conference and clarifies and elaborates, with a proclamation composed by 27 articles called *principles* with concepts already updating and taking considering the development and growth needs of developing countries by inserting 4 new documents: the *Agenda 21* (to indicate the main environmental impact actions to remember and achieve in the 21st century); the *climate convention*; the *convention for the conservation of biodiversity*; *statement on global consensus on sustainable development*.

The 1997 the "*Kyoto Protocol*" on climate change endorsed by almost 10,000 delegates from 160 countries, defined the policies and measures for the reduction of greenhouse gases (Bolin, 1998). The Protocol

promotes research on alternative energy and on incentives for sustainable economies and forms of cooperation between industrialized and developing countries with the commitment to reduce emissions between 2008 and 2012 by 5% compared to 1990 levels.

In 2002 the "*World Summit on Sustainable Development*" was held in Johannesburg, attended by 191 national governments, UN agencies, multilateral financial institutions and other major groups to assess progress since Rio. The Johannesburg Summit was important because contributed to define specific outcomes:

- A political declaration
- The Johannesburg Plan of Implementation
- Specific partnerships for a common goal.

Key commitments included those on sustainable consumption and production, water and sanitation, and energy.

After the historical summit in Copenhagen, in 2009 have been in Paris the meeting on climate known as "*COP 21*". Almost 40,000 participants had the common goal to reduce the temperature by 2 degrees, below the levels of the first industrial revolution (1861-1880) from 2015 to 2100 (or 2.900 billion tons of CO2, or a cut of the order between 40 and 70% of the emissions by 2050).

The objectives are reviewed in the context of national commitments every 5 years. The Paris agreement came into force in 2016, following the fulfilment of the conditions for ratification by at least 55 countries representing at least 55% of global greenhouse gas emissions. All EU countries have ratified the agreement. The agreement signed in Paris had the merit of being the first of a binding nature and global scope for combating climate change.

Work on the instruments for implementing the Paris agreement continued at "*COP 23*", which was held in Bonn in November 2017. This summit was more research than dialogue. In this context, Italy has led the way by playing an important role with the choice of coal output by 2025 and by joining the global coal stop alliance, which was born during COP23. It is necessary to see if it is of announcements to which concrete facts will follow, how to promote more ambitious goals to produce energy from renewable sources.

However, if the various countries do not raise the targets under discussion to achieve a better climate by 2030, everything will have been

useless. SD is an engine that moves the world policy in many domains, from economy to environment, society and education. Even if the alarm of climate change is increasing a new model of economy focused on emission reduction and respectful for the environment should be implemented, the efforts are not enough.

SD is the development that meets the needs of the present generation, without compromising the ability of future generations to meet their own needs. The approach is based on the balance of different and sometimes competing needs in contrast with environment, social and economic limitations the society faces. Moreover, development is focused on specific needs without taking into consideration the environment and its impact in the future (Giddings et al. 2002). SD takes into consideration the relation between the environment and the balance of human needs, from the more basic to the most complex drivers that push us to make specific decisions that have a direct impact in the economy. In fact, if economic development is conducted with the depletion of natural resources, SD scope is to ensure strong, healthy and just society, meeting the diverse needs of all people in the present and in the future communities, by promoting wellbeing, social cohesion, inclusion and equal opportunity in the society (Figure 1).

Fig. 1. Relationships in sustainable development – environmental, social and economic concerns. (Source : https://sisu.ut.ee/env-intro/book/1-1-sustainable-development)

The principle is to find better solutions that have direct effects on the quality of life, leading benefits in the short, medium and long term (Robinson, 2004). Effectively the decisions we make as active consumers affects our lives and have an impact on the entire ecosystem and the only way to make better decisions is act sustainable collectively to achieve a real change. Governments, civil society, enterprises must play the same role together to achieve effective SD results.

3. World energy sector and global emissions

The International Energy Agency (IEA) reported in the "*Global Energy and CO2 Status Report, 2017*" the global energy demand. From their studies, the total demand increased by 2.1% in 2016, more than double compared to the previous year, namely for the strong economic growth worldwide. Oil, gas and coal have satisfied 70% of the increase in energy demand and renewable energies have recorded impressive gains and greater growth compared to all other fuels.

The improvement in energy efficiency has slowed down and for the first time since 2014, and global carbon dioxide emissions linked to energy have increased by 1.4%. Carbon emissions reached 32.5 gigatons in 2017 with impressive amount in United States, the United Kingdom, Mexico and Japan. Moreover, oil demand grew by 1.6%, more than double compared to the average annual rate recorded in the last decade, driven by the transport sector and the increase in petrochemical demand (IEA, 2017).

Renewable energies recorded the highest growth rate among all fuels, satisfying a quarter of the increase in global energy demand, while the production of electricity from renewable sources increased by 6.3%, driven by the expansion of the wind, solar and hydroelectric power. Energy efficiency improvements have slowed considerably, with an overall energy intensity improvement of just 1.7% in 2017 compared to an average of 2.3% for the period 2013-2016, due to apparent slowdown policies to support efficiency and reduce energy prices (IEA, 2017).

The consumption of natural gas has grown by 3%, of which almost a third comes from China alone and 80% from world demand is linked to the construction and industry sectors. The demand for coal has

increased by around 1%, reversing the trend recorded in the previous two years, thanks to the increase in the production of electricity from coal, especially in Asia. In 2016, fossil fuels accounted for 81% of total energy demand, a stable level for over thirty years.

Emission are steady connected to the energy sector, even if more than 40% of global population does not have access to energy grid.

In particular, we focus our attention on the Central Africa, where the condition of the population is poor and the access to basic services is limited to the most populated cities. In fact, we studied a country with effective attention, in order to conduct our research for the cooperation project financed by the University La Sapienza of Rome. We analysed the case study of Kenya, where from the last census the total population counts around 41,609.700, and continues to grow at a high rate: within twenty years it has almost doubled and the share of the young population, with less than fifteen years, is very high. The population density is high in the inner region of the highlands, while the coastal strip is scarcely inhabited, except for the area of Mombasa. The urbanization rate is high, with 45% of the population gathered in urban areas that are spreading. The urban population thickens especially in the cities of Nairobi, the capital, and Mombasa, an Arab city on the coast.

A recent study by the Institute of Security Studies on the 10 most populous countries of sub-Saharan Africa showed that Kenya ranks the sixth position among the poorest countries, according to the Extreme Poverty Index. It turns out that, unless radical measures are implemented, the country will not be able to fight the condition of extreme poverty that is gripping 18 million people by 2030. The reasons for the slowdown in achieving the goal by 2030 are social and economic inequalities, poor management of resources and constant population growth: Kenya must invest in primary education, infrastructure and methods to reach the poor (Cilliers et al., 2017).

4. Kenya and rural communities, an overview

Kenya is one of the largest states in the world and its territory covers an area of 582,646 km2. It borders Ethiopia to the north, Somalia to the east and overlooks the Indian Ocean, Tanzania to the south and Uganda to the west. Until 2013, the country was organised in eight provinces, the

provinces divided into districts and the districts divided into localities and sub-locality. The new constitution of Kenya came into force in 2013, and was started a reorganisation of the provinces in counties. In Table 1 and Figure 1 we reported a classification that is useful for understand the structure of the country (Figure 2 and Table 1).

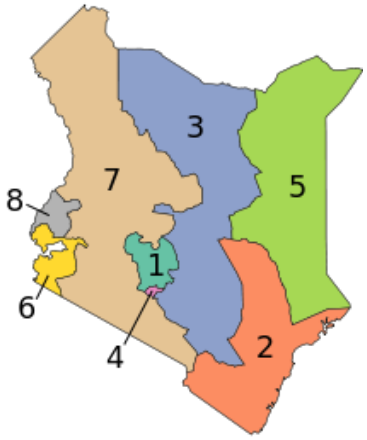

Fig. 2. Provinces in Kenya according the legislation until 2013, map.

Tab. 1. Kenyan provinces until 2013
(source: Kenyan Central Bureau of Statistics)

Number	Province	Km²	Description
1	Central Province	13,191	Area around the capital Nyeri, has 12 districts and is one of the largest producers and exporters of coffee.
2	Coast Province	83,603	Along the Indian Ocean with the capital in Mombasa, has 13 districts.
3	Eastern Province	159,891	Bordered to the north by Ethiopia, to the east and to the south by the North-East Province and the Coast Province and to the west by the Central Province, Nairobi Province and Rift Valley Province, with the capital Embu, has 26 districts.
4	Nairobi Province	696	Coincides with the city of Nairobi and has 3 districts, entirely urban.
5	North Eastern Province	126,902	Bordered to the east by Somalia, to the north by Ethiopia, to the south by the Costa Province and to the west by the Eastern Province with the capital Garissa, has 10 districts. It has large refugee camps, most of the refugees come from Somalia.

6	**Nyanza province**	16,162	Bordered to the north by the Western Province, to the east by the Rift Valley Province, to the south by Tanzania and to the west includes a part of Lake Victoria with the capital in Kisumu, has 18 districts.
7	**Rift Valley Province**	173,854	Bordered to the north with Sudan, to the east with the Eastern Province, Central Province and the Nairobi Province, to the south with Tanzania and to the west with Uganda with the capital at Nakuru, has 36 districts.
8	**Western Province**	8,361	Borders to the north and east with the Rift Valley Province, to the south with the Nyanza Province and to the west with Uganda with capital in Kakamega, has 16 districts. It has many sugar factories and the largest paper factory in Africa.

The economy is mainly based on agriculture where almost 70% of the population works. Agriculture is classified essentially into two types: *industrial agriculture* with large coffee, tea, cotton, sugar cane, potato, tobacco, wheat, peanut and sesame plantations; and *indigenous agriculture* (practically personal and family subsistence) based on cultures of maize, cassava, beans, sorghum and fruit. Cattle is a common practice, differentiated in industrial breeding to produce meat, milk, dairy products, leather and wool; and the practice diffused in the nomadic tribes of Kenya, who consider their cattle their most valuable assets.

An effective issue of Kenya is namely related to the *problem of energy access*. In fact, even if in the district of Nairobi and the West province (corresponding to number 1 and 8 in Figure 2 and Table 1) have the access to energy and electricity because the concentration of people is high and the basic services are provided to the population, the rural areas face a difficult situation in many zones. One of the most important problem is the energy access and the scarcity of energy resources inside the country. The main source for the energy generation is related to several coal and hydrocarbons, where wood fuels represent the main source of energy for the population. In fact, over 400 million of people in the country do not have access to electricity, mostly living in villages. Accordingly, to the IEA report (IEA, 2014) Congo and Uganda are the "darkest" countries, Ivory Coast and South Africa the most "enlightened". Only in Mauritius, 100% of the population has electricity. South Africa follows with 67% and Ivory Coast with 50%. The most critical case is that of Uganda where only 5% of the population has electricity. In the Democratic Republic of Congo only 7% of the population has electricity, in *Kenya* 9%, in Madagascar 9%, in Togo 10%, in Tanzania 12%, in Burkina Faso 13%, in Cameroon the 20%, in

Senegal 30%, in Nigeria 40%, in Ghana 45%.

Moreover, the number of people without light seems destined to grow (IEA, 2014): in the last 25 years in Africa electricity consumption has increased by 15%, compared to the doubling of the population in the same period. If this imbalance continues, the continent's future will always be blacker. Even today millions of people in Kenya live with no connection to the national electricity grid and the most of these people live in the county, where only 5% of the electricity supplied in the country reaches, and where three Kenyans out of four do not have energy services (BP, 2016). Worldwide, African country consumes only 3% of the world's electricity: network connections are limited to the main cities and are unlikely to reach the countryside and the cost of electricity in Africa is among the highest in the world (IEA, 2014). For these two conditions, Africans still use traditional woody biomass and fuel.

5. Biomass and energy employment as solution for energy access

The term "*biomass*" refers to a series of materials of biological origin. These are generally agricultural waste, which can be modified through various processes to obtain fuels or directly electricity and heat (Athanasiou et al. 2007). The biomass can be differentiated into two different categories:

1. Biomass form cultivation: such as wood, corn and cereals in general, sugar;
2. Biomass from waste: such as twigs and residues of agricultural and forestry activities; food waste; liquid waste arising from farms.

All these materials can be used for three purposes:

- Biofuel: direct production of biological fuels such as bioethanol, biodiesel, synthetic hydrocarbons and vegetable oils obtained by fermentation of vegetables rich in sugars (such as sugar cane, beets and corn), pressing or other chemical processes and which can be used as fuel for endothermic engines, instead of petrol;
- Biopower: generation of electrical and thermal energy obtained directly by burning the woody biomass (logs of wood or pellets) in high-performance boilers or cogeneration plants;

- Bioproduct: realization of chemical compounds such as biogas, obtained through a specific anaerobic digestion process and used for the direct generation of energy or as a fuel.

Easily we can affirm that energy from biomass can be produced from any material of organic-vegetable origin (trees, plants, agricultural or industrial residues, urban waste), and the interest in this commodity is considered more as a valid resource for the environment than a contribution to energy shortages. Therefore, the growth and the conscious use of the large amounts of vegetation present in the territory contribute to improving the ecosystem through a greater absorption of carbon dioxide. The use of plants powered by biomass energy makes it possible to carry out the "*carbon cycle*": the quantity of carbon emitted resulting from their use is identical to that absorbed by the plants to produce the same amount of biomass (Bright et al., 2012).

Another convenient technology to produce electricity consists in the direct combustion of dry biomass. Since the beginning of 2000, the use of biomass as a heating fuel has had a significant increase in Europe and China, mainly thanks to pellets. In 2010 in Europe it is estimated that 10 million tons (MT) of pellets have been consumed, which in 2020 will double to become more than 23 MT. In China, over the same period, it will increase from 1 MT to 10 MT. Overall, worldwide will increase from 15 MT in 2010 to 45 MT in 2020. In Italy, consumption has gone from under 100,000 tons in 1999 to over 3 MT in 2015 (IEA, 2016).

Form another perspective, the World Health Organisation (WHO) in the early 2000 has started to investigate on the direct relation between environmental and health impacts regarding the use of biomass from wood. In fact, in least developed countries and in the poor and rural economies the reduced access to the energy grid determines the use of biomass form wood as the main source of energy for thermic purposes, especially for cooking (Yamamoto et al., 2009). This use has direct impact on environment and on health, with specific effects on deforestation and greenhouse gas emissions. The greenhouse gas emissions derive from the not complete combustion from cooking over open fire and have direct effects on acute respiratory infections. However, even if this common practice of transforming wood biomass for cooking purposes and for facilitating the access to the energy grid leads to deforestation, inefficiency

and illness, this modality remains the most used in the developing countries (IEA, 2014).

Biomass represent an opportunity to promote universal access to clean energy is the background. In our study we focused on analysing biogas technology application in order to:

- contribute to the implementation of SD practices and 2030 Agenda;
- promote a conscious use of natural resources management for contribute to the reduction of harmful practices, such as deforestation, pollution and decrease of human health conditions.

During my experience in Kenya, I came across a case study of a company operating in the country, producing innovative simple technology to promote the energy access in rural areas based on the employment of biomass from waste. The company invented and labelled an easy technology that could guide the substitution of wood-biomass employment with the reuse of food waste. The biogas system can also support the green economic growth, addressing the main challenges the country is handle such as unemployment, poverty, food insecurity, energy access.

Fig. 3. Flexible biodigestor plant

6. Our case study on Kenyan communities: innovation and sustainability

The company we analysed in our case study operates in the industry of energy production from recovery commodities. The company has been

created in 2011 in Nairobi, spending many years in research and development stages to guarantee to their products sustainability and efficiency. The company focuses its business idea on simplicity, affordability and ease of operation in solutions to daily challenges that will benefit the people and assist in poverty eradication. The team design the tools in order to use locally available materials and where necessary, off the shelf components to easily assemble the tools and contact local technician in the region (Figure 3).

Tools and equipment are designed to make the process simpler for the rural farmer, offering sustainable and affordable total energy solutions, all in *environment-friedly* modality. Many of our products are custom designed to suit the needs of a clients, and we are always designing new gadgets on suggestion of the users. Among the products offered by the company, the most innovative product is a flexible biogas compound that does not required high technology process, but the aim is to delivery an effective solution to substitute the wood biomass with organic waste for energy production. The system the company offers is based in different component:

- polyethylene pillow
- pipelines
- plastic cover

In this system, the biochemical process is the same that occurs in the fixed biodigester, and the final product is the biogas that is produced in the polyethylene pillow and transported directly inside the house of the family, in order to be converted and transformed in energy for cooking and lighting purposes.

The system is simple and need only from 7 to 10 days to be installed. The material needed for the generation gas can be an amount equal to 15-30 kg of cow manure per day or the equivalent of 20 kg of other animals' dugs, as well as kitchen waste, market waste, grass.

Tab. 2. Models and characteristics of biodigester

Model	Persons	Capacity (m3)	Price (US$)
Standard	8-10	6	695
X-large	18	9	845

For our project we analysed a small district located near the capital Nairobi called Machakos. The district counts a population of around 1,098,600 people where the 51% are female and 49% male (African census 2009). The population is young, counting the 46% for the category age 0-17 and 49% for the category age 18-64, while the over 65 are represented by only the 5%.

The district reflects the economic activity of the country, based on agriculture and cattle as main activities. The literacy index in the area is low: 10% of the population is illiterate; 58% have the primary education; 20% the secondary education; only 1% have a university degree. Female gender has the high rates of non-attendance or school dropout (16%) than male gender (7%). The main motivation of this difference between the two groups is for the tradition and the culture of the population, where women must take care of the domestic tasks (Oloo, 2013). As representative of this aspect is the percentage of employment rate: the female inactive population represents almost 165,000 people on the total female population.

In our research we wanted to demonstrate the linkage between the usage of wood biomass on the CO2 emissions, in relation to the level of education and time spent by female group for the supply of wood natural resources.

We apply a statistic model called mediation, in order to define the effective relation between the variables studied and to support our thesis with qualitative and quantitative analysis.

7. Empirical evidence: methodology and results

To understand the relation between environment, economy and society variables we analysed a sample composed by a representative population in a county of Machakos, reflecting the composition we explained in the paragraph 5. We used the model of mediation (Miller, 2007), to demonstrate the effective relation between the "use of wood biomass" (X) with the amount of "emissions released in the natural environment" (Y). We considered two variables as elements that influenced the statistic relations between X and Y and we highlighted as fundamental variables: "time spent for the supply of natural resources" (A1) and "level of education" (A2) (Figure 2).

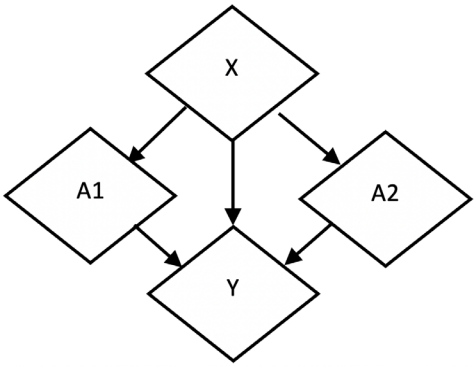

Fig. 4. Graphic representation of the relation between variables

Our goal is to evidence numerically that acting on the education of the population is possible to have a positive output on the environment. Moreover, we want to demonstrate that improving the condition of women is possible to improve the condition of live for the entire family. Switching from wood biomass to waste is possible to reduce the emissions released in the environment, implementing the circular economy framework.

In the statistic results we derived from the model, we confirmed that there is a causal relation between the variables of the system: the fuel used by the population is related to the emissions released in the natural environment. Moreover, we had the evidence that the variables A1 and A2 compromise the results: improvements in education can lead indirectly to a reduction of co2. The correlation coefficient of the system is significant and for A1 is equal to 0.4 and for A2 is equal to 0.3.

We launch also the Sober test for the model to estimate the total effect and demonstrate that the significance is significantly different from 0. For the variable A1 and A2 the Sobel test confirmed that the model is good, with values of 1.1 and 1.2 respectively.

In this way, the revaluation of biomasses indirectly improves the health conditions of rural populations, as confirmed by the low impact of this material in the energy generation process.

8. Conclusions

The flexible innovative system that processes the agro-food residues with a simple and rapid diffusion technology represents a typology of biodigester that facilitates the access to more efficient systems of energy generation, even in those countries where there is lack of access to the energy market. This technology is part of a sustainable development mechanism linked to the strong sustainability approach, increasing the level of growth of the company according to the four dimensions on which the sustainable development paradigm is based.

While the measures of economic growth referred exclusively to the increase over time of the real national product per capita, the concept of sustainable development considers in addition the social behaviour as a result to be achieved in growth, implementing measures of redistributive justice and intergenerational equity (Pearce, 1988).

The revaluation of agri-food waste in this innovative system allows the population to access to energy generation systems that have less impact on the environment and human health, improving the conditions of the population in developing countries thanks also to the reduction of climate change emissions.

The flexible type of biodigestion system contributes to the implementation of SD, improving the conditions of the rural population with different implications:

- economy: reducing spending on the purchase of energy raw materials;
- social conditions: improving health conditions, education and the quality of life of the rural population;
- environment: decreasing the release of dangerous substances into the natural environment, reducing the stress on natural resources and decreasing the environment degradation.

Thanks to this type of biodigester system, is possible to eliminate the activity of wood biomass collection and women and children can dedicate the extra time (we calculated around 3-4 hours per day) to other activities such as studying. The system can improve also the best practices, adding value to farm products thanks to the

output of the product of the biodigester. In this way it is possible to elevate the poverty conditions of many families in rural areas, facilitate the access to energy market and reduce the negative effects on environment (Baiyegunhi, 2014), such as degradation, pollution and deployment of natural resources.

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