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Innovate Africa

Executive summary

"Innovate Africa" is a project with the objective to boost the Next Production Revolution (NPR) in Africa, while keeping a focus on the peculiar features of each country.

The weak infrastructural tissue and the Climate Change threat pose a serious challenge for the future socio-economic development of the Continent, which needs to leverage on its strengths (e.g. possibility to exploit renewable energies) to foster the NPR development.

To this end, a flexible and modular technological kit impacting directly on Water, Energy and Food (in line with Nexus framework) has been designed. Following a logic of optimization of resources, the project promotes a flexible approach in which actors (inhabitants of rural villages) can be an active part of the process (creating the kit they need to take advantage of it) and the final solutions would be extremely adapted to the context (therefore, untransferable and unique).

Indeed, in the frame of the project, the kit has been customized to the specific needs and peculiarities of three sub-Saharan Africa countries, deemed to be the most promising Countries for NPR development: Ethiopia, Kenya and Congo. Therefore, the final output is the configuration of the kit and the consequent final layout for 3 case study villages of 50 people each in the three analyzed Countries.

Conventional and high-tech technologies with a direct impact on Water, Energy and Food (WEF) have been combined, aiming at improving agricultural productivity of rural villages. In particular, the kit will enable water purification, green energy production and precision farming, enhancing village inhabitants living standards.

In conclusion, the kit is a structured but adaptive technology pack, with the main objective to support The Italian Agency for Development and Cooperation and Politecnico di Milano and Politecnico di Torino to find a sustainable pathway that can lead Africa out of poverty through innovation and the implementation of NPR

Key Words

Africa, Innovation, Next Production Revolution, Flexibility, Context.


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Project description written by the Principal Academic Tutor

The *Innovate Africa* project has the aim to understand how the Next Production Revolution (NPR) can be a leverage to socio-economic development in Sub-Saharan Africa through an investigation of some sustainable innovations tailored to the local context, including rural population.

The adopted approach to NPR wishes to focus on the development of solutions about the two clusters of technologies more suitable for the local context: digital and green technologies. Therefore, the confluence of integrated solutions that enable Energy, Mobility and Digitalization are deepened in order to induce substantial improvements and affect both technological and socio-economic development.

The project has a common bond within the collaboration of the ASP students with a group of the African Innovation Leaders (AILs) to enable, all along the project, the exchange of information and experience between Italian and African realities throughout the whole definition of the work.

The AILs belong to the first group of African professionals selected within the project supported by Italy during the Presidency of the G7 in 2017 and funded one year later by the Italian Agency of Cooperation and Development. The project is jointly managed by Politecnico di Milano and Politecnico di Torino[1].

More in details the project was developed by following a step-by-step structure, resumed as follows:

1- Contextualization and Country studies: during this phase, the current state of the art for the national innovation systems has been analyzed, after selecting the Sub-Saharan countries: Ethiopia, Kenya and Congo. These countries and their innovation ecosystem would represent the field of application of the solutions.
2- Main issues identification: in the context of the whole Sub-Saharan Africa, the major problems and themes of investigation have been identified and selected. They are mostly related to access to resources and common goods, like food and water security as well as the threat to ecosystem services posed by climate change and therefore the urgency of proper mitigation policies.
3- Technological exploration: after understanding the key aspects to be faced, a set of both conventional and high-tech technologies has been identified and solutions have been formulated. A development kit represents the technology sharing instruments to be provided to rural areas in order to start enabling and facilitating the seeds of the needed NPR in those areas.
4- Application of the solutions: the proposed modular kit has been differently assembled for a standardized village in the three countries in order to fulfill local needs, according to the specific political and economic constraints that characterize each country. Solutions are selected based on their suitability in the local areas and their costs.

At the end of the project work, part of the team was involved in a mission in Mozambique aimed at interacting with local authorities and experts in the field, trying to understand the opportunities for practical implementations of the project and further extend the usability of the development kit. Within this mission, which was of high relevance for the team's understanding of local boundary conditions, a visit to a rural village was organized to share the "development kit" and receive a feedback by the inhabitants of rural areas as perspective beneficiaries of the tool.

[1] Please visit the page http://community.africainlead.net/

Team description by skill

The *Innovate Africa* team is made of six students: Iacopo, Cristina, Luca, Marta, Giacomo and Olivia. Each member of the team possessed individual skills and shared with the other teammates his or her specific knowledge.

The fields of expertise of the team varied from Architecture to Management Engineering; thus encouraging a holistic approach when addressing the issues revolving around the project. The team was efficiently organized, allowing each team member to develop his or her abilities. The team, infact, decided to elect a team leader, **Giacomo Ferrari**, but to maintain a non hierarchical structure in order to favor a more creative and dynamic environment. Giacomo Ferrari is a Management Engineer from Politecnico di Milano and with **Luca Marzorati**, coming from the same Magistrale programme, helped coordinating and organizing the team tasks. Their role was essential in the creation of the project structure and during the interactions with the stakeholders and with the African Innovation Leaders who were crucial during the idea generation phase.

In this phase, the role of the three architects in the team was also of major importance. **Marta Riccò**, **Cristina Mordeglia** and **Olivia Boccardi** were fundamental during the brainstorming stage thanks to their ability to identify the main problems of the current reality and propose unconventional and innovative solutions. The three architects thanks to their skills were also in charge of project communication.

Fnally, **Iacopo Ciuchi**, with his background in Energy and Nuclear Engineering, was the main reference for all of the more technical aspects of the project. His role was fundamental since the project's main topic is Energy. Furthermore, Iacopo was very helpful in the interaction with architects, collaborating with them he contributed to the creation of an otherwise less realistic and feasible project.

Goal

The main goal of the project is to identify a solution able to trigger the Next Production Revolution in sub-Saharan Africa.

Considering the needs and the constraints posed by the different stakeholders - i.e. the Italian Agency for Development and Cooperation (AICS), Politecnico di Milano and Politecnico di Torino, African Innovation Leaders (AILs) and ENI - a series of other goals emerged. In particular, the proposed solution has to have a direct impact on Water, Energy and Food, fitting the WEF framework and being feasible from a technical and an economic viewpoint. Moreover, agriculture has been recognized as the most promising area of intervention and specifically agricultural productivity improvement of rural sub-Saharan villages has been chosen as the main goal.

However, the Continent shows a high level of diversity in terms of natural resources, infrastructural tissue, people habits, et cetera. For this reason, the proposed solution has to be suitable for different contexts (represented in the project frame by three rural villages in Ethiopia, Kenya and Congo) and consequently flexibility, modularity and adaptability result to be core characteristics.

Therefore, the final goal of the project emerged to be the design and configuration of a flexible and WEF-Nexus-compliant solution aimed at improving the agricultural productivity of rural sub-Saharan Africa villages and villages inhabitants standards of living. Combining traditional and high-tech technologies, the proposed solution should become the trigger of a leap-frogging process to boost the Next Production Revolution in sub-Saharan Africa

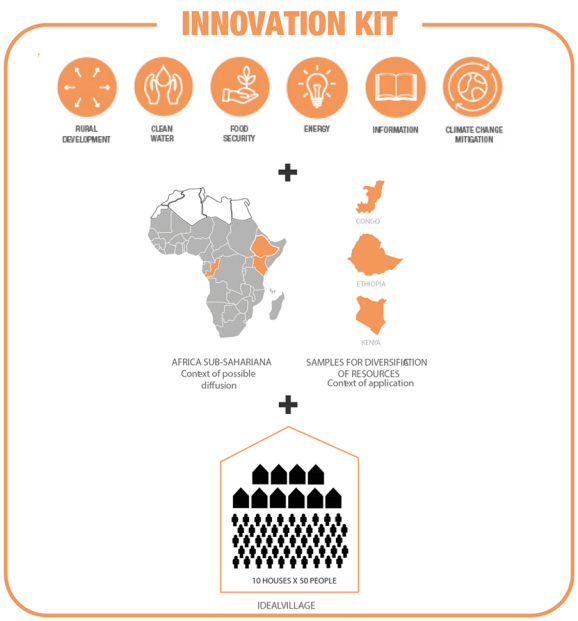
Understanding the problem

NPR requires the support of both hard (e.g. water and electricity supply) and soft (e.g. governance mechanisms) infrastructures to be boosted and an analysis of them is the starting point of the work. With a twofold objective (i.e. understand the state-of-the-art and identify the main potentialities) the overview of African infrastructures is grouped in three macro-areas: Digitalization, Decarbonization and Mobility. Among all, Decarbonisation and, thus, the reliance on more sustainable energies, is of fundamental importance in a Continent where population and economy are increasing, continuously requiring larger amounts of resources.
Mobility and Digitalisation reveal to be crucial as well: if the first is a prerequisite for the growth and innovation of a Country, the second can increase the possibility to access to basic services requested by the society, while fostering the productivity in different sectors. This is particularly true for agriculture, the most impacted segment in "Innovate Africa" project.

The second step of the work is the identification of the most promising Countries for NPR development in sub-Saharan Africa (Kenya, Ethiopia and Congo) and an in-depth study of their peculiarities. Kenya is a worldwide case study for its exploitation of M-Pesa, the mobile application for money transfer largely adopted in the country, which, thanks to digitalization, represents a model of leapfrogging for other nations. Ethiopia and Congo are a fertile ground for the study of possible innovations in agriculture: the first is still heavily reliant on the primary sector, while the second is embracing a Governmental diversification strategy that should decrease the dependence on the industrial segment, allowing improvements in agriculture and in its productivity.

Then, the problem is considered from a broader viewpoint and environmental safeguard is set as a priority. For this reason, the agricultural studies are considered in relation with the global issue of Climate Change and respecting the paradigm of Water-Energy-Food (WEF) Nexus, which is an enabler for the creation of synergies between the three clusters, that can be considered as pillars for agriculture improvement. The key to keep together the WEF with a climate change mitigation vision is then identified in the use of renewable energy to fulfil agricultural and water issues and demand. The extensive presence of hydro, solar and wind resources should represent a breakthrough in understanding which technological, economic and political strategies need to be involved in order to fully exploit their potential. In particular, technological solutions involving renewables are perfectly suitable to African reality, where around 60% of the people live in decentralized areas, far from the cities: the most representative example is constituted by PV panels, whose small capacity and modularity are the fundamentals for a diffusion of a technology in those parts of the world where electrification is very low or, even worse, absent.

To sum up, a series of initial analyses are carried out to frame the problem and the surrounding context. In particular, the state-of-the-art and the potentialities of the infrastructural tissue of Africa are analysed in depth. Then, the analysis moves to the identification and the study of the most promising sub-Saharan Africa Countries for NPR development. Finally, the Climate Change threat is taken into consideration and the WEF Nexus framework is presented.



Africa Innovation Kit

Exploring the opportunities

After understanding the current problematic situation of sub-saharan Africa, the major issues to be considered has been recognized into:

1- Rural development;
2- Clean water supply;
3- Food security;
4- Renewable energy supply;
5- Information spread;
6- Climate change mitigation.

In order to include and take into account every factor, a set of existing technologies has been selected and collected in a Development Kit to be provided to rural areas, trying to improve their inhabitants lifestyle in a sustainable manner. The chosen technologies are:

- Solar assisted pumps, whose aim is to exploit more the local resource of groundwater and surface water to irrigate agricultural fields with an almost completely sustainable energy supply: PV panels. They have clearly a different design if they are used to pump groundwater or surface one.
- Solar water disinfection (SODIS), that consists in a 25 liters Polyethylene tube surrounded by a solar parabolic concentrator, that aims at focusing solar irradiation on the tube in order to kill patogens. Moreover, water needs to be pretreated from turbidity. Consequently, two alternative solutions are proposed, namely the use of natural flocculants extracted by specific seeds or roughing filtration systems.
- PV driven Reverse Osmosis filtration (PV-RO), a more effective alternative to SODIS in providing potable water. It can be used also for water dissalation, being able to remove even very small ions dissolved in it.

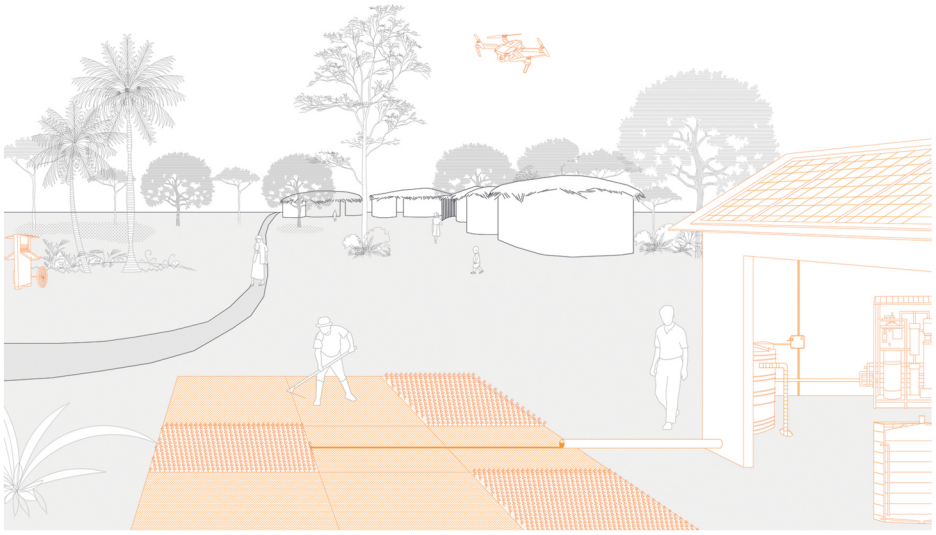
- Anaerobic Digester, used for biogas production from agricultural waste. It promotes the idea of a closed system that could reuse the waste to produce a fuel that has an energy value and can be used for cooking purposes.
- Fertilizers and Urea Deep Placement (FDP and UDP), that are an alternative to traditional surface broadcasting of fertilizers across fields, consisting in fertilizer briquettes, placed at different depths below soil surface, that gradually release nitrogen according to different cultivation requirements.
- Aeroponic system, that, thanks to the fact that plant roots are suspended and directly sprayed by nutrient solutions without the use of soil, makes possible to recover disadvantaged cultivation areas, offering an alternative to overcome the difficulties linked to the fertility of land.
- Aerial agriculture and Variable Rate application Technology (VRT), that are used, respectively, to monitor the characteristics of the fields and to acquire data from sensors for the automation of inputs rate for site specific applications in a "smart agriculture" view.
- Solar Wi-Fi, needed in order to enable the previous smart agriculture systems. Following the idea of renewable systems, a solar powered network of kiosks is provided to convert energy from the sun into internet connection.

Generating a solution

Once identified all the technologies that can compose the kit, the project group has identified the potentiality of its application in three different 50 people standardized villages, respectively located in Kenya, Ethiopia and Congo. As a matter of fact, the kit is not unique and does not necessarily comprehend all of the technologies mentioned before, but can be assembled according to the specific needs of the single village, taking into account geomorphological, economic and political features.

Therefore, the final outputs are the choice of the three different configurations of the kit for the three case study villages and the visual representations of their assembling, highlighting how the technologies can be spatially disposed in the rural environment.

Finally, the different versions demonstrate the versatility of the system and are directly comparable in terms of investment costs for the different components (which depend on the resources and the limits of the country) and feasibility.



Final configuration of a rural village in Kenya

Final configuration of a rural village in Ethiopia

Final configuration of a rural village in Congo

Main bibliographic references

[1] P. Leone, M. Taisch, F. Cheli M. Pinzone, S. Arrigoni, C.F. Chiasserini, P. Boccardo, E. Colombo, «Toward Smart and Integrated Infrastructure for Africa: an Agenda for digitalisation, decarbonisation and mobility,» Infrastructure Consortium for Africa, 2017.

[2] World Economic Forum, "The Africa Competitiveness Report 2017.", Geneva, 2017.

[3] Deloitte, "Industry 4.0 - Is Africa ready for digital transformation?.", 2016.

[4] Organization for Economic Cooperation and Development, " The Next Production Revolution- Implications for Government and Business.", Paris, 2007.

[5] African Development Bank, «African Economic Outlook,» 2018.

[6] P. Garrone, F. Lamperti, «Country Study- Overview of the National Innovation Systems: Ethiopia.».

[7] B. Mrkajic, «Overview of the National Innovation Systems for the Emerging African Innovation Leaders, G7 Exchange and Empowerment Program – Kenya,» 2018.

[8] S. Tavneet, J. Williams, «The economics of M-Pesa,» 2010.

[9] A. Calzadilla, T. Zhu, K. Rehdanz, R.S.J. Tol, «Economy wide impacts of climate change on agriculture in Sub-Saharan Africa,» Ecological Economics, 2013.

[10] H.T. Aboelnga, M. Khalifa, I. McNamara L. Ribbe, J. Sycz, *The Water-Energy-Food Security Nexus: A review of Nexus literature and ongoing Nexus initiatives for policymakers*, Nexus Regional Dialogue Programme, Bonn 2018, pp. 20-26.

[11] IRENA, *Africa Power Sector: Planning and Prospects for Renewable Energy* (2015)

[12] FAO, "Climate-Smart Agriculture", www.fao.org.

[13] P. Pavelic, M. Giordano, B. Keraita, V. Ramesh and T. Rao, Groundwater Availability and Use in Sub-Saharian Africa: A review of 15 Countries, International Water Management Institute, Colombo, 2012.

[14] P. Ferna and E. Ares-Maza, Evaluation of the Solar Water Disinfection Process (SODIS) Against Cryptosporidium parvum Using a 25-L Static Solar Reactor Fitted with a Compound Parabolic Collector (CPC), 86:2, 223–228, 2012.

[15] M. W. Mbiyu, Use of aeroponics technique for potato (Solanum tuberosum) minitubers production in Kenya, Journal of Horticulture and Forestry 11:4, 172-177, 2012.

[16] African Union and The New Partnership for Africa's Development (NEPAD), Drones on the horizon – Transforming Africa's Agriculture, High Level APET Report, 2018.