# Barriers to the use of equipment design methods in West Africa


## ABSTRACT

Growth in the agricultural and agri-food processing sectors is crucial to food security and economic development in West African Countries. In Burkina Faso, local equipment manufacturersplay a leading role in these fields. Furthermore, equipment design methods and tools have evolved from a linear approach to parallel engineering. Indeed, they integrate major context-specific constraints such as manufacturing, maintenance, and the user's point of view.This work aims to carry out a literature review of equipment design methods and tools applied in West African Countries, and to analyze their adoption by local equipment manufacturers. This enabled us to identify the methods and tools used, and the difficulties encountered by local equipment manufacturers in adopting them. These difficulties include: the lack of training of local equipment manufacturers the unfamiliarity and complexity of the methods and tools, and above all the unsuitability of the methods for the understanding of local equipment manufacturers, since they were initially intended for design teams. As a result, we were able to envisage a design approach close to local equipment manufacturers perception. Field surveys will enable us to refine this study and formalize a new, simplified approach adapted to the perception of local equipment manufacturers.



*Keywords: Design tools and methods, Local manufacturers, Design teams, Agri-food and agricultural equipment,*




## 1. INTRODUCTION

The mechanization of agriculture and agribusiness is a major challenge for the development of West African countries (WAC). When actors in the sector need high-performance equipment adapted to local conditions, they usually turn to locally produced equipment [1]. However, while locally manufactured equipment meets the need for proximity, it often has limitations in terms of performance and reliabilityand according to [2] cited by [3], the reliability of equipment is often linked to its design. To improve the competitiveness of such equipment and to meet the specific needs of farmers, many innovative design methods have been developed. [4]highlights the diversity of design issues and the need to develop a range of adapted methods. [5]lists about forty methods, of which value analysis, QFD and NPD are the most widely used. Methods specific to the context of developing countries have also been proposed, such as the CESAM method (Conception d'équipements dans les pays du Sud pour l'agriculture et l'agroalimentaire) ) [6]or the DFMSN developed by [7]. The latter aims at improving the availability of equipment in small agri-food units in West Africa.[8-12]have proposed tools and methods for integrating logistics, maintenance and food hygiene and nutritional quality into equipment design.[13]proposes a methodology for an integrated approach to equipment eco-design in agro-equipment manufacturing SMEs. Several other studies, in particular those [14, 15]and [16],have proposed design tools and methods to consider the user and the socio-technical network in the design process. Despite the

relevance of these methods and tools, their adoption by local manufacturers remains limited.This study aimis to highlight the literature on design methods and tools used in WAC for the design and manufacture of agri-food and agricultural equipment. This study will analyze the difficulties associated with the adoption of these methods and tools, and then propose possible solutions for their acceptance by local manufacturers.

## 2. MATERIAL AND METHODS

First, the research question was clearly formulated: What are the barriers to the adoption of industrial engineering design methods and tools? The scope of the study was then narroweddown to the agricultural and food sector in West African countries.Databases such as Google Scholar, Scopus, Web of Science, CASSI and JSTOR were used to search for scientific journal articles and dissertations on equipment design and manufacturing. Finally, these articles were analyzed to identify the methods and tools used and any barriers to their use.

We define local manufacturers (LM) as those who manufacture, sell and/or install agro-food and/or agricultural equipment. They are able to read industrial plans and have a level of education limited to the higher diploma. Planning team: a multidisciplinary team with a level of education higher than the baccalaureate that carries out design and/or production projects.

In the rest of this article, we'll look at design methods such as the traditional method, which is defined as a sequential, structured approach to product design. It is characterized by a linear progression through defined stages with minimal backtracking. [17]presents a traditional design process. Frugal design is a design approach that aims to create efficient, high-quality solutions using a minimum of resources [18]. User-Centered Design (UCD), which places the user at the center of the development process, is a methodological approach that aims to understand users' needs, expectations, and behaviors in order to design solutions that are useful, usable, and desirable to them. The so-called agile methods, which have similarities with UCD, are new methods that are being proposed in new design projects. Initially developed for software development, they have gradually gained ground in other fields, notably industrial engineering. Their use in industrial engineering has been tested by [19]. The Experimentation-Modification(EM) design method is an iterative approach to design in which a prototype is created, andtested under real or simulated conditions, strengths and weaknesses are identified, and necessary modifications are made before the cycle begins again. The steps are described in [20]. According to [21], low cost is a strategic approach that aims to significantly reduce the cost of producing a product or service while maintaining sufficient quality to meet consumer expectations. The world of design has not remained on the sidelines of artificial intelligence, as we are witnessing the birth of generative design. This is a revolutionary approach to computer-aided design (CAD) that uses artificial intelligence and algorithms to generate multiple design options based on specific parameters and constraints. [22] shows the changes that the development of a generative design system will bring to manufacturing.

## 3. RESULTS

The following table lists 20 small-scale projects for equipment for the agricultural and agro-food sectors in West African countries.

**Table1. listing agricultural and agri-food equipment design and manufacturing projects.**

| No. | Equipment project | Method | Tools | Country |
|---|---|---|---|---|
| 1 | Tuber cutter [23] | Functional analysis | HornedBeast<br>Octopus diagram<br>FAST<br>CAD<br>Prototyping | Burkina Faso |
| 2 | ATESTA Dryer [24] | Functional analysis | Octopus diagram<br>Functional Specifications<br>FAST<br>MCA<br>CAD<br>Prototyping | Burkina Faso |
| 3 | Grain threshers [25] | Functional analysis | Octopus diagram<br>Functional Specifications<br>FAST<br>CAO<br>Prototyping | Burkina Faso |
| 4 | Direct seeder [26] | UCD | CAD<br>Simulation<br>Prototyping | Bénin |
| 5 | Hybrid solar dryer [27] | Frugal conception | CAD<br>Simulation<br>Prototyping | Bénin |
| 6 | Portable maize dryer [28] | Traditional Method | CAD<br>Simulation | Ghana |
| 7 | Séchoir de feuilles de Moringa [29] | Traditional Method | CAD<br>Prototypage | Ghana |
| 8 | Hammer Mill [30] | Redesign | CAD<br>Simulation<br>Prototyping | Ghana |
| 9 | Rotary roaster [31] | Traditional Method | CAd<br>Prototyping | Ghana |
| 10 | Forced Convection Solar Dryer [32] | Traditional Method | Prototyping | Guinée |
| 11 | Amaranth seed drill [33] | Low-Cost conception | CAD<br>Prototyping | Nigeria |
| 12 | Motorized plantain slicer [34] | Traditional Method | CAD<br>Prototypage | Nigeria |
| 13 | Cereal Grinder [35] | Traditional Method | CAD Simulation<br>Prototyping | Nigeria |
| 14 | Manual Hydraulic Palm Oil Press [36] | Frugal conception | CAD<br>Prototyping | Nigeria |
| 15 | Bicycle Sprayer [37] | Traditional Method | CAD<br>Prototyping | Nigeria |
| 16 | Dual Function Seed and Fertilizer Spreader [38] | Traditional Method | CAD<br>Prototyping | Nigeria |
| 17 | Dryer for pounded yam | Traditional | CAD | Nigeria |

| | | | | |
|---|---|---|---|---|
| | flour [39] | Method | Prototyping | |
| 18 | Semi-automatic cassava planter [40] | Frugal conception | CAD Prototyping | Nigeria |
| 19 | Direct seeding under vegetative cover with animal traction [41] | Experimentation-Modification | CAD Prototyping | Nigeria |
| 20 | Design of organic manure spreader [42] | CESAM | Prototyping | Togo |

**Design Methods Used in Equipment Design Projects**

The figure 1 shows the different design methods used in the agricultural and agro-food sector in WAC.

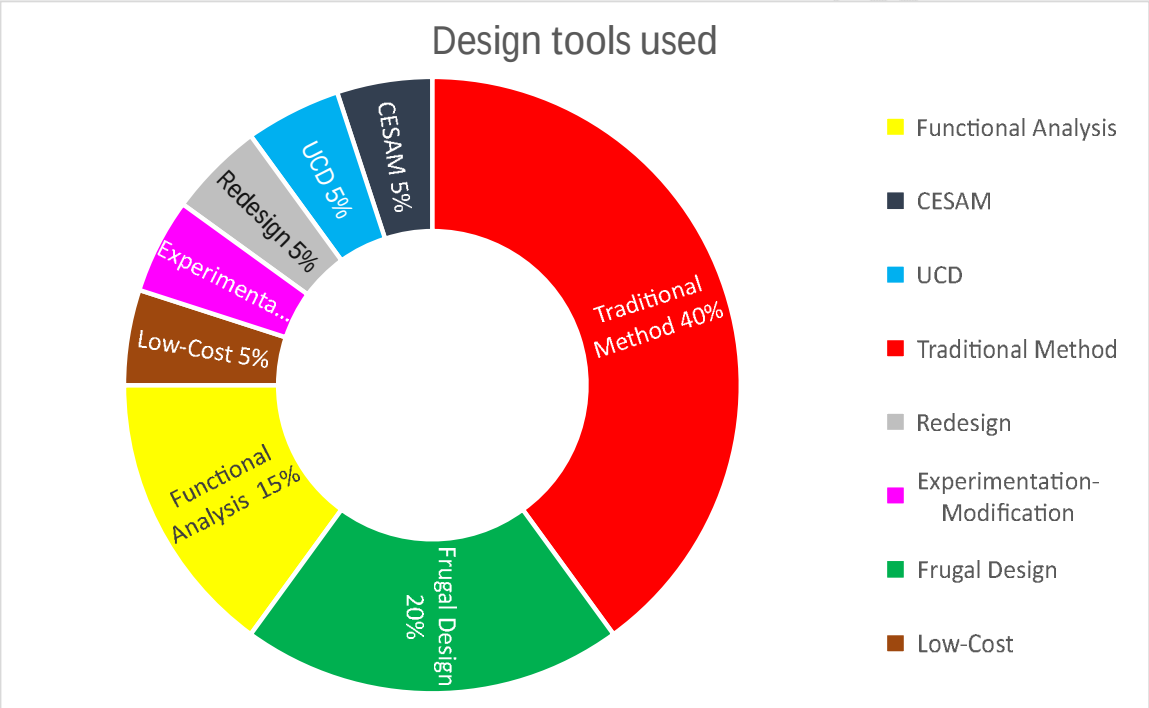


**Fig.1.Design methods used in West African countries for the design of agricultural and agri-food equipment.**

It clearly shows that the traditional method is the most widely used with a representation of 40%. This observation of the dominance of the traditional method had already been highlighted by [6], but the difference is that today we are witnessing the use, albeit timid, of other design methods such as the Frugal method at around 20%, followed by Functional Analysis at 15%, which shows that design teams are beginning to optimize the equipment development cycle. Several factors may explain this situation. First, the other methods may be less well known. Second, they may be more complex and costly to implement. Finally, these methods may not be suitable for WAC.

**Design Tools Used in Device Design Projects**

The figure below shows the design tools used in West African countries.

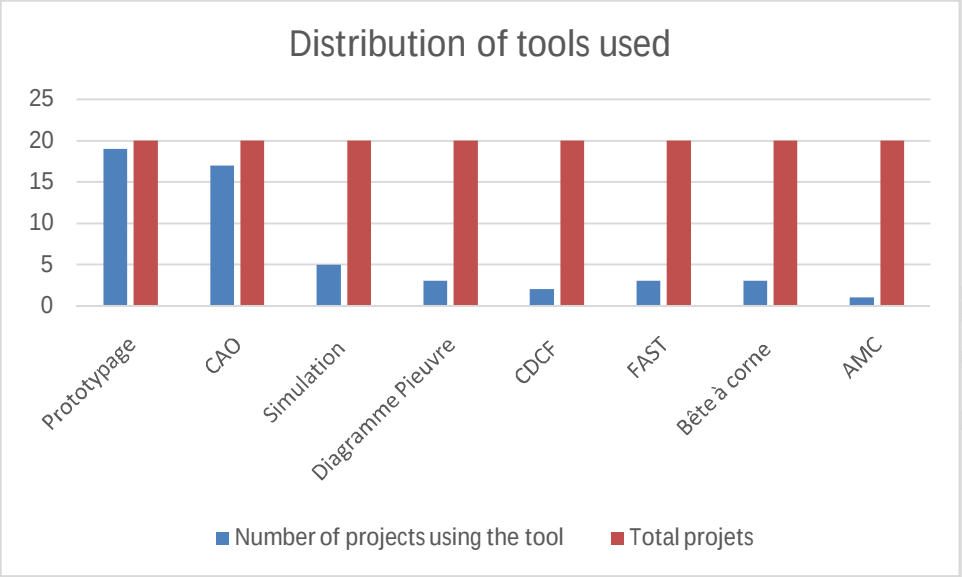


**Fig.2.Design tools used in West African countries to design agricultural and agri-food equipment.**

Figure 2 shows that the most commonly used tools are prototyping and computer-aided design (CAD). The dominance of these tools can be justified by the fact that they significantly speed up the design and production processes, while reducing the costs associated with product development. What's more, they act as mediating objects [43], fostering effective collaboration between design teams.

Simulation is increasingly used because design teams have a better understanding of CAD. However, tools such as the octopus diagram, Functional Specifications, and FAST are not widely used because they are likely to require more time and a multidisciplinary team, thus increasing development costs. Other design tools, such as FMEA [43], or in general tools that use quantitative or qualitative criteria, are also little used. These criteria, which are generally measurable or evaluated, require the use of historical data, which is often not available. The question is why tools that use feedback from design teams to evaluate these criteria are not used.

The limited uptake of design methods and tools may be due to several constraints:

- Lack of awareness and lack of training. In fact, the introduction of design methods into academic training in West African countries is late. In Burkina Faso, for example, these methods are only taught as part of the university curriculum. This limits the capacity of LFs to adopt and promote these new methods.

- Complexity: Design methods can be perceived as difficult or too complex to implement, which can discourage potential users.

- Stakeholders' perceptions of these methods are a critical factor in their adoption. Fears or simple habits can act as barriers to the use of new tools.

- The cost of adopting certain design methods is a major barrier, particularly for LFs whose customers tend to have low budgets. This observation leads these manufacturers to work with limited budgets, thus limiting the use of design tools and methods.

**Discussion**

This work revealed a diversity of methods and tools used in the design of agricultural and agri-food equipment in West Africa published scientific papers. It also highlights the most commonly used methods and tools and shows a progression in the adoption of these tools and new design methods. Although the results are indicative of current practice, it is likely that the inclusion of unpublished work, particularly from local manufacturers, will alter these trends slightly. Nevertheless, our findings on the methods used do not contradict those of previous studies [6, 12, 14, 16].

Although many barriers to the use of design methods and tools have already been identified in the literature [44], our study provides an exhaustive summary of these constraints. This detailed compilation makes it possible not only to establish a precise state of play, but also to identify avenues of improvement for wider adoption of these methods in our specific context, which are as follows:

-Early integration of design tools and methods into training could be considered,

- Developing design methods and tools that are more intuitive and easier to use,

- Developing communication campaigns to promote the benefits of design methods and demonstrate their effectiveness.

-Encouraging networking between professionals in the field to create a community for sharing and exchanging good design practice.

These solutions could form the basis of future research to facilitate the use of design methods and tools by local manufacturers.

## 4. CONCLUSION

Our study revealed that the majority of agricultural equipment designs in West Africa are based on the traditional method (40%), followed by frugal design (20%) and functional analysis (15%). It should be noted that prototyping and computer aided design (CAD) are the most commonly used tools in design projects. Despite these advances, the adoption of modern methods is still limited by a lack of training, the perceived complexity of the methods and financial constraints. This study also opens up perspectives for future research, in particular on the adaptation of design methods to the constraints and realities of local manufacturers.

Finally, the next step will be to conduct an exploratory field study to analyze unpublished work and the evolution of equipment design in order to optimize these approaches and make them more accessible to local actors. This will require close collaboration between researchers, local manufacturers and training institutions to develop solutions tailored to the specificities of the West African context.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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