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SUMMARY

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RESEARCH ARTICLE OPEN ACCESS

BIODIVERSITY CONSERVATION INITIATIVE IN NEPAL

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ABSTRACT

The study aims to assess the biodiversity conservation initiative in Nepal. The focus group discussion, score ranking, key informant interview, field observation methods were used to collect the information from the study areas. The study focused on Terai Arc landscape, National Conservation Areas and Sacred Himalayan Landscape of Nepal. In the areas around 5000 ha forests have been restored in different critical corridors and 1085 ha grassland had been managed across TAL which has supported in improving quality habitat for Tiger, its prey based species and other wildlife species. The overwhelming majority of the respondents (98.63%) have found happy with the programs because the improvement of sustainable livelihoods of the poor people, conservation of species and ecosystem conservation, sustainable forest management, alternative energy and conservation education and capacity building of women, men, youths, ethnic groups and conflict affected people. There has been increased species population like tiger, rhino, snow leopard, blue sheep etc; increased community stewardship, habitat restoration and livelihood enhancement. The program launched with government and civil society organizations that lead to sustainability of the program. There have been faced challenges in order to wildlife conservation that include human-wildlife conflict, limited resources, transboundary movement and wildlife trade etc.

I. INTRODUCTION

I.1 BACKGROUND

Nepal is South Asian mountainous country in the lap of the Himalayas. Eighty five per cent of land area is classified as under mountainous and hills. Biodiversity is defined as the "variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes or which they are part; this includes diversity within species, between species and of ecosystems" [1]. UNEP (1995) has stated that the biological species are regularly explored along with scientific and technological innovations at the global level. The distribution and magnitude of the biodiversity that are explored today is a product of over 3.5 billion years of evolution, involving speciation, migration, and extinction which are largely affected by human influences in recent years. Recent estimates indicate the presence of various biological species ranging from 7-20 millions, of which 1.75 million species are scientifically described [2].

Uprety (1998) has explained that Nepal has about 54% of the surface area under some sort of vegetation. A total of 118 ecosystems have been identified in different physiographic zones. In addition, 75 vegetation types and 35 forest types are identified which is bioclimatically, divided into ten zones. Besides the larger number of deep valleys, the considerable vertical extension of the Nepal Himalayas has contributed to the formation of many isolated localities, which may have favored for the creation of new species. Nepal contains only about 0.1% of total landmass of the world while it harbors about 2% of flowering plants, 3% of pteridophytes and 6% of bryophytes of the world's flora. In addition, about 5% (246 species) of the total flora reported is endemic to the country. The endemic species accounts to about 30 % for whole of the Himalayas. Based on the current level of species recorded, Nepal could be considered as a meeting point of several floral species because of altitudinal and climatic

variations [3]. Manandhar has pointed out that most Nepalese depend on plant resources for their livelihood. Traditionally, people of Nepal have considered forests as a source and a symbol of creation [4]. Thapa has stated that more than 134 wild edible plants have been identified in Nepal. The rural people have been taking roots, tubers, rhizomes, leaves, and fruits derived from wild sources during the food scarcity period [5]. The biodiversity conservation work is directly related to livelihoods of the indigenous people as well in Nepal.

MOFE has stated that even before the adoption of the United Nations Biological Convention (1992), the Forest Nationalization Act 1957 is one of the pioneer policies of its kind. This policy had an intention to protect the public forests from individual misuse and encroachment [6]. Dhakal has further elaborated that Nepal has formulated biodiversity conservation policy from local to central levels. The Constitution of Nepal gives an especial attention to all three tiers of the government to conserve, manage and use biodiversity resources as a concurrent subject matter. The National Parks and Wildlife Conservation Act (1973), Forest Act (1993), Environmental Protection Act (1994) and control of International Trade of Endangered Species of Wild Fauna and Flora Act (2017) and their subsequent regulations are the visible policy reforms for biodiversity conservation in Nepal [7]. However, biodiversity conservation practice from the community people is the age old tradition of Nepal.

Terai Arc Landscape (TAL), Sacred Himalayan Landscape (SHL) and National Conservation Priority Area (NCPA) programs have been launched in Nepal in order to conserve the biodiversity. TAL and SHL programs are being implemented by Department of National Parks and Wildlife Conservation (DNPWC) and Department of Forests (DOF) with technical and financial support from WWF-Nepal. The project is being run under co-management system between Government of Nepal and WWF as agreed by scope of cooperation between Ministry of Forest and Soil Conservation and WWF every five year. A total of 55 districts out of 77 were covered by the programs across the country. The intended beneficiaries include women; ethnic groups, Dalits, youths, and conflict affected people and vulnerable groups of the communities in the program areas.

I.2 BACKGROUND

The objectives of the study are to:

1. Assess the performance of the biodiversity conservation program to make difference in the lives of vulnerable population, and
2. Analyze the effectiveness and sustainability issues maintaining good relation with plants, people and wildlife towards biodiversity conservation.

II. MATERIALS AND METHODS

The participatory approaches and methods were adopted by involving the project stakeholders primarily the direct right holders in general using a combination of qualitative and quantitative tools for data collection. The gender equality and social inclusion was taken into account while carrying out the study. The focus group discussion, key informant interview, direct observation, score ranking methods and review of documents was adopted to collect the information. Similarly, project publications were reviewed as secondary source of information. The people's perception towards the programs as stated in the plan have been figure out and conducted the comprehensive analysis from different perspective. A total of five districts were selected as sample purposively based on the ecological belt, representation from poor, women, ethnic groups, and conflict affected people from the study areas. The study has limitation due to sample survey. It could not cover the whole study areas due to large population and geographical coverage.

III. RESULTS AND DISCUSSIONS

III.1 EFFECTIVENESS AND IMPACT

The Terai Arc Landscape including Corridor and Bottleneck Restoration, Sacred Himalayan Landscape and National Conservation Program Area supported by WWF in the study areas. These programs have brought positive changes in the lives of women, men, children, ethnic groups, youths, and conflict affected people. In the study areas, TAL focused more on Rhino and Royal Bengal Tiger conservation whereas SHL has focused more on snow leopard and red panda conservation. They have been linked with sustainable lives and livelihoods of the local people particularly focusing to buffer zone area of national parks. More than 5000 ha forests have been restored in different critical corridors. Likewise, 1085 ha critical grassland had been managed across TAL which has supported in improving quality habitat for Tiger, its prey based species and other wildlife species.

III.1.1 Happiness Mapping Towards the Programs

When asked about the perceptions of local people towards biodiversity conservation program to overall performance, the respondents have been replied and scored 1,654 (70.38 %), 664 (28.25 %) and 32 (1.36 %) for very happy, happy and unhappy (poor) condition respectively. The large majority of the respondents (98.63 %) have rated very happy and happy with the programs because of the improvement of sustainable livelihoods of the poor people, conservation of species and ecosystem conservation, sustainable forest management, Climate Change Adaptation, alternative energy and conservation education and capacity building of women, men, youths, ethnic groups and conflict affected people. Few respondents (1.36 per cent) rated the program unhappy for not getting direct tangible benefits. The happiness mapping tool was used to map out the perceptions towards satisfaction of the people (Table 1). A total of 50 corn seeds assumed as 100 per cent were given to every respondent. A total of 47 persons participated in the exercise. The community perception was mapped out based on their direct observation, experience and best judgment of the respondents. This was measured in relative terms. The frequency represents the scoring of the respondents on set parameters.

Table 1: Happiness Mapping towards the Programs.

Parameters	Frequency	Percent
Very Happy	1654	70.38
Happy	664	28.25
Unhappy	32	1.36
Don't Know	00	00
No Response	00	00
Total score	**2350**	**100**

Source: Author, (2017).

The community perception mapped out during the study which is presented below:

"There has been conflict between wildlife and human-being particularly caused by wild boar, tiger, rhino, elephant and

deer species in our area. Chitwan National Park has provided 30-50 per cent amount of income to buffer zone community for the purpose of community development, conservation education, income generation program etc. In the last year, we have spent NPR 3.2 million including conflict resolution budget (NPR 2 million). We have done PCC wall construction, 10 KM road construction, received fund from GoN, Ministry of Finance (NPR 15 million) for 5,265 meter road construction. The mess wire PCC fencing has controlled about 100 per cent wild boar and 90 per cent rhino infestation into the private land. He further stressed that the relationship between wildlife and human-being will be improved if there is no damaged the crops by wildlife in private land" says Mr. T. N. Adhikari-40, Office Secretary, Buffer Zone Kerunga Forest Users Group, Chitwan National Park.

III.1.2 Before and Now Situation Mapping in Amaltari, Nawalparashi

The score ranking tool was used with the participation of Community based Anti-Poaching Unit in Baghkhor village of Amaltari BZUC, Nawalparasi in Chitwan National Park which included community women and men to measure the effectiveness of key program activities of TAL and NCPA in the communities (Table 2). When asked on before and now situation mapping, what were the changes observed in the community, the respondents scored the main impacts of program in plant, people and wildlife.

Table 2: Before and After Situation Mapping in Amaltari Community-based Anti-Poaching Unit.

Main Impacts	Before (August 2012)	Now (June 2017)	Reasons
1.Forest conservation	6 (60 %)	9 (90 %)	• Increased conservation awareness • Organized grassland • Protection of wetland etc • Increased community patrolling
2.Wilflife Population	3 (30%)	8 (80 %)	• Increased no. of Rhino from 5-35 • Increased no. of Tiger from 2-6 • Increased no. of deer from 10-100 • Observed new species of bird (Mottle wood Owl-a kind of *Latokosero*)
3.Life of Rivers (Narayani) around 6 KM distance	3 (30 %)	7 (70 %)	• No use of insecticides in River • Plastic free • Organized collection of stone, gravel etc • Controlled fishing
4.Interrelation ship between Plant, Wildlife and Human-being	4 (40 %)	7 (70 %)	• Increased Plantation • Rescued of injured wildlife • Zero poaching happened in this area • Wildlife closed by with community

Source: Author, (2017).

The Amaltari, Nawalparashi Community based Anti-poaching Unit (CBAPU) was formed in 2014. There are a total of 300 members in the group where 40 per cent women and 60 per cent men have been organized. This is a volunteer value-led youth group. They are actively engaged in biodiversity conservation work in the buffer zone of Chitwan National Park. They have formed executive committee where a total of 15 members (40 % women and 60 % men) have been elected from the general members. They have own office building. They have done significant works in order to biodiversity conservation that include: Patrolling in day and night, Narayani River cleaning, plantation, awareness rising to school children, conservation campaign, ecotourism etc. They have faced challenges as well that include direct conflict with wildlife. However, they became successful for zero poaching until eight years.

At the community level, the significant changes as perceived by respondents which are as follows:

- Development of self-reliant economy
- Economic prosperity happened among community members
- Diversification of enterprises
- Improved public health-health education, sanitation and personal hygiene
- Increased social harmony
- Reduced child and maternal mortality
- Increased self-esteem among women
- Developed local leadership and local institution
- Increased bargaining power among CBAPU members to influence policy and practice at local level.

III.2 SUSTAINABILITY

Sustainability is a major issue of the most of the development projects in Nepal due to high incidence of poverty, weak management capacity and poor governance system. In this program, the implementing partner organization Ministry of Forest and Soil Conservation, Department of Forests, Department of National Park and Wildlife Conservation and local civil society organizations has taken measures for the continuation of the Terai Arc landscape, Sacred Himalayan Landscape and National Conservation of Priority Area issues in the future. Furthermore, Nepal Army has been engaged using mobile-based technology (GPS), CC camera etc in 24 hour duty in order to promote and conserve the forest and wildlife particularly in TAL, SHL and NCPA programs.

Similarly, Forest Caretakers (Ban Heralus-women and men) are also engaged in conservation works using mobile based technology (Table 3). They have felt proud with getting limited incentives as well. There has been formed Buffer Zone Forest Committees, Buffer Zone Forest Users Groups, Eco-Clubs formation and Council level network in the program areas. Government of Nepal has provisioned the conservation of forest and wildlife in each priority areas. Similarly, Government has initiated number of long term programs particularly focusing to conserve the endangered species like Royal Bengal Tiger, Asian Rhinoceros, Asian Elephant, Snow leopard, Red Panda, River Dolphin, and Gharial etc. There has been developed the linkage, coordination and collaborative woks with government line agencies and service providers for the continuation of the services as well.

Table 3: Before and now situation mapping of forest and wildlife in Chitwan National Park as perceived by Ban Heralu.

Parameters	Before (2072)	Now (2074)	Reasons
Control deforestation	4 (40 %)	7 (70 %)	Mobile based technology Dedication of *Ban Heralu*
Control wildlife poaching	5 (50 %)	9 (90 %)	Dedicated effort of Nepal Army People awareness Actively engagement of CBAPU Coordination between stakeholders
People's awareness raising	4 (40 %)	9 (90 %)	Conservation education Mobile based technology

Source: Author, (2017).

The researcher discussed with Ban Heralu to map out their contribution in biodiversity conservation which is presented below:

III.2.1 Shramik Duna Tapari Small Industry

The laborers have organized and established the NTFP based Duna Tapari cottage industry in Kawashoti, Nawalparasi district in 2015 and registered in Department of Small and Cottage Industry. A total of 700 members (540 women and 160 men) are organized in this cottage industry. It has reported the transaction of NPR 700,000.00 (seven hundred thousand, 1US$ =117 NPR) in last year. We have planned to increase transaction around NPR 2,000,000.00 (NPR two million) in the next year. In this industry, a total of 278 people are directly employed where a woman earned net NPR 84,000 per year. They sell their products in Narayanghat, Pokhara and Kathmandu valley. This industry has been led by Mr. R. P. Pandey.

There have been changes observed in the life of members which are as follows:

- Children are enrolled in boarding school for education
- Leadership Development in politics as well as other social sector
- 12 months food security
- Constructed the RCC building as shelter
- Improved nutritional status of the poor people
- Improved secure livelihoods of the poor and vulnerable families
- Increased self-esteem among women and poor men due to self-employment generation.

"The program supported by WWF to establish NTFP based small industry has been instrumental in making a difference in the life of poor and vulnerable families. I am happy with this industry. I have earned NPR 450,000.00 last year. It has contributed a lot to run my livelihood. Now, I become an industrialist. My life has been transformed from landless laborer to industrialist. I am very proud from it. We have envisaged the future plans that include: extension of other NTFP based industry like broom grass, bamboo baskets, rope etc and increase direct self-employment for 700 people in the next year. However, we have needed NPR 1,000,000.00 (one million) and management training to expand our industry. We would like to request to WWF for further support in our plan" says Mr. Pandey, R. P. - 42 June 2017, chairperson, Jyoti Kunj Community Forestry, Kawashoti, Nawalparashi and leader of Shramik Duna Tapari Small industry, Kawashoti.

III.2.2 Institutional Sustainability

Poudel (2016) has pointed out that Nepal Army is now providing security to nine National Parks and 3 Wildlife Reserves deploying 7,627 military officers and personnel. Since April 2015, Nepal Army has also deployed its 849 personnel in Dhorpatan wildlife reserve and Makalu Barun National Park. Nepal Army has established Nature Protection Institute to further strengthen nature conservation work. Due to its vigilance, Nepal has been able to mark Zero Poaching Years in 2011, 1013 and 2015. Nepal Army has been playing a key role in protection of wildlife and natural heritage. Out of 20 protected areas, Nepal Army has been protecting 12 areas [8].

Nepal pioneered the use of Real-time SMART patrols in 83 guard posts in all tiger-bearing protected areas of TAL. This new patrol techniques developed by the Nepal Army in collaboration with WWF Nepal makes use of an android–based platform on mobile devices through which patrol teams record and update patrolling and location data in real-time. It has allowed for 24-hour monitoring of patrol teams together with providing immediate instructions on the ground, made the patrolling teams accountable, increased area coverage and frequency, and provided for paperless and prompt reporting to the headquarters. This is the latest technology to curb poaching and aid enforcement efforts within protected areas [9].

The study team conducted key informant interview with Colonel Mr. Thapa about the effectiveness of Chitwan National park conservation work particularly supported by Nepal Army that was interesting and amazing work in order to conserve the forest and wildlife. "The main weapon is the self-discipline and unity of efforts for wildlife conservation. This is a team work. Nepal Army is doing 24 hour patrolling in order to anti-poaching operation. We are using mobile based technology developed by Nepal Army which is useful to monitoring the movement of army and others in any time and from any place. There have been faced challenges in order to wildlife conservation that include human-wildlife conflict, limited resources, transboundary movement and wildlife trade etc. There is a need of repair and maintenance of high tech equipments in the national park area" says Colonel Mr. M. Thapa, Nepal Army, Chitwan National Park, 2017.

The local institution is an engine of community development including biodiversity conservation to make a difference in the life of poor women and men. WWF has initiated a Digo Gaon (sustainable village) concept where an integrated program has been launched. This is a pilot project supported by TAL program. It has gained momentum in positive trend towards resilient livelihoods and biodiversity conservation as well.

Similarly, the study team has carried out the key informant interview with Chief Conservation Officer Mr. Kanel about the effectiveness of Chitwan National Park conservation work over the last five years. During the interview, he pointed out the critical views on the conservation work supported by WWF Nepal in Chitwan National Park. "There has been increased conservation of wildlife species and forest, reduced dependency, increased fencing work to improve relationship between wildlife and buffer zone community, initiated self-employment generation schemes, fishery, capacity building training, celebration of world wildlife day, community incentive programs, reduced incidence due to people-park program, wetland conservation etc. National Park has allocated 30-50 per cent income to buffer zone community development works. He has identified as gaps that WWF should fully follow the participatory planning process; Chitwan National Park should lead and own the planning process. All conservation programs should be launched through Chitwan National Park whereas WWF should work as facilitator" says Chief Conservation Officer, Chitwan National Park, 2017. There is co-management system existing between GoN and WWF in order to run the TAL, SHL and NCPA programs. There has been reported some coordination problem between CNP and TAL management team due to misunderstanding. It needs to be resolved through mutual respect and dialogical process between Chitwan National Park and WWF, TAL program.

III.2.3 Baghkhor Sustainable Village Nawalparashi

The score ranking tool was used with the participation of women and men of sustainable village in Baghkhor, Nawalparashi buffer zone of Chitwan National Park to measure

the impacts of sustainable village of TAL and NCPA at the buffer zone community level. When asked on before and now situation mapping regarding the changes observed in the community, the respondents scored the main impacts of program in plant, people and wildlife using certain outcome indicators (Table 4).

Table 4: Impact on Baghkhor Sustainable Village, Nawalparashi, Chitwan National Park Buffer Zone.

Parameters	Before (Aug 2012)	Now (June 2017)	Reasons
1.Economic Development • Self employment • Formation of Cooperative • Ecotourism (Homestay)	2 (20 %)	6 (60 %)	Ecotourism-75 HHs, skill development, diversification in agriculture, formation of cooperative-220 members, Increased economic prosperity and reduced poverty.
2.Social Development • School Education • Improved in Public Health • Access to Water, Sanitation and Hygiene • Good Governance and Culture	2 (20 %)	7 (70 %)	Access to safe drinking water-100 % HHs, establishment of community health clinic, protection of culture, increased social harmony, organized public auditing and organized regular meeting.
3.Environmental Conservation • Forest, wildlife, Climate Change Adaptation, environmental Friendly behavior and zero poaching	1 (10 %)	6 (60 %)	Zero-poaching until eight years, management of wetland and grassland, construction of forest trail, mess wire (5.5 KM area, Electric fence (8.5 KM area), plantation, established nursery, construction of checkdam and regular patrolling etc
4.Interrelationship between Plant, Wildlife and Human-being	3 (30 %)	8 (80 %)	Forest and wildlife conservation, and established good relationship between wildlife and human-being due to awareness rising among women and men.
5.Leadership Development/Local Institution Development	2 (20 %)	8 (80 %)	Developed local leadership Increased women awareness Increased self-esteem among the women.

Source: Author, (2017).

III.2.4 Issues and Challenges

Human-wildlife conflict continues to be a major challenge in TAL. While conservation efforts have helped increase wildlife populations especially of tigers and rhinos, this in turn has escalated the level of such conflict in TAL. The incidence of a rhino entering the streets of Hetauda bazaar is a vivid example of how HWC (human wildlife conflict) might escalate in the future if appropriate mitigation measures are not in place [9].

III.2.5 Technical Sustainability

The fish enterprises have becoming lucrative business for the people living in buffer zone areas (Box 1) particularly in Madi, Chitwan. A case study has been presented below:

Box 1: Fishery Enterprises

Similarly, the fishery enterprise seems to be profitable as compared to traditional crop like rice. It produces 200 kg fish per Katha that cost around NPR 50,000 (fifty thousand) whereas rice produces 150 Kg per Katha that cost NPR 3,000 (three thousand) only. The fishery enterprise has becoming popular in Gopalnagar, Madi, Chitwan where a total of 800 ponds are being used for fish culture. Farmers sell their products in Narayanghat, Pokhara and Kathmandu valley. There is no major problem of marketing. However, there has been problem noted in order to repair and maintenance of old ponds and control of magar gohi as predator. Farmers from Gopalnagar sell the fish around NPR 70 million per year where a total of 102 households have been engaged in fish farming (Fig.10). They have formed fish cooperative as well in order to promote the fish enterprises. After fish farming, there has been controlled 90 per cent wildlife infestation in the village. Government of Nepal, Ministry of Agriculture has declared Madi as pocket area of fish. So that farmer will get more support from Government of Nepal. The magar gohi should be translocated from Gopalnagar to Narayani River.

III.2.6 Financial Sustainability

The financial sustainability of the program and local institutions is crucial aspects for long lasting. In the project areas, there has been formed Buffer Zone Forest Users Groups, Buffer Zone Forest Users' Committees, agricultural cooperatives, saving & credit groups, commercial vegetable farming using plastic tunnel, livestock enterprises, poultry farming, dairy industries, NTFP based enterprises and ecotourism (homestay) program activities have been operated with the local leadership. The National Parks also allocated about 30-50 per cent income to buffer zone community development. The public hearing or public auditing events at Buffer Zone Forest Users groups and Buffer Zone Forest Users Committees organized in order to promote financial transparency and to control and prevention of misuse of resources. However, there is a need of capacity development of executive committee members in this.

III.3 COORDINATION AND COMPLIANCE

WWF Nepal works with community partner and government agencies from local to district and central levels in program planning, implementation and monitoring. Field project office has close coordination with DDC and other district level government agencies. WWF Nepal also intensively engaged at different central level mechanisms to work on policy formulation, national level coordination; and resource mobilization. WWF Nepal shares all the policy and research documents to the government agencies as well as other stakeholders. It has strong partnership with Ministry of Forests and Soil Conservation and its departments: Department of National Parks and Wildlife Conservation and Department of Forests. Government of Nepal and conservation partners work closely with technical expertise and financial resources to achieve the conservation results. WWF Nepal has followed the terms and conditions provisioned in the general agreement and project agreement made with SWC.

Project implementations has been done under co-management system where government representatives deputized as a project lead and play critical role in ensuring co-ordination with local level authorities and partners on the ground whereas central level project steering committee and project executive committee provides policy guidance and support with strategic direction in implementations. WWF has organized the transboundary meeting with China and India as well in order to solve the transboundary issues related to illegal trade of wildlife and fire control etc. China-Nepal Memorandum of Understanding (MOU) on cooperation in the field of forestry and biodiversity conservation (2010) is under implementation through the support of WWF particularly in organizing local level transboundary meetings. A local level transboundary meeting between China (Tibet Autonomous Region-TAR) and Nepal was organized on 25th April 2015 in Dhunche, Rasuwa, Nepal. The meeting delegates discussed about the cross-border conservation issues particularly forest fire and illegal wildlife trade in the border areas [9].

WWF (2014) has stated that an event of regional trans-boundary meeting between India (Sikkim) and Nepal organized on 17 February 2014 in Gangtok, India to enhance trans-boundary cooperation. The meeting decided to continue cross-border joint monitoring to identify and address conservation issues; and strengthen information and communication systems between the two countries to stop poaching and illegal trade of wildlife and plant parts. Snow leopard research in Nepal and red panda research in India was shared in the meeting and agreed to collaborative research on flagship species through common understanding on methodologies and information sharing [10].

III.4 GENDER EQUALITY AND SOCIAL INCLUSION (GESI)

The WWF set a broad GESI goal as: "By the end of 2018, WWF's all program and projects practice will be more gender and social responsive and inclusive," taking the first step towards making the program more responsive and inclusive. This broader impact will be constantly supported, enriched and achieved through constant feedback from field project implementation, peer engagement in the planning process, and incorporation of national policy with its contemporary context. These would accelerate positive changes in conservation practices, making them more gender and socially inclusive. The WWF team also aimed to develop a more comprehensive reference guideline; build CBOs' implementation capacity, enhance understanding on gender and conservation, and promote an enabling environment to achieve higher impact. WWF Nepal's future focus envisaged on building the capability of local natural resource management institutions by helping in their human resource Development and providing training and orientation to local resource persons, respective project staff, social mobilizers and implementing partners in the landscapes programs, and performing periodic social and gender auditing of all targeted activities [11].

The Forest users Groups, Buffer Zone Forest Users Committee and agriculture cooperatives are the backbone of the TAL, CBRP, SHL and NCPA programs. There has been changed in the traditional gender roles of men and women where women farmers participate in the community meeting whereas men go to jungle to fetch fuel wood and fodder. At present, this has been a normal phenomenon in the society. The gender issue has been taken into account in the assessment-design-implementation-monitoring of TAL and SHL programs.

In the study areas, the participation of women (around 55 per cent) in the development process has significantly increased particularly in decision-making process at households, community and municipality level. There has been narrowing down the gap in traditional gender roles and division of work in women and men. However, women have still more engaged in domestic chores whereas men have focused more in seasonal migration and plough the land. In case of access to and control over resources, women have also increasing greater influence within household and even in the community level resources due to the positive impacts of the conservation programs. The Buffer Zone Forest Users Groups and Buffer Zone Forest Committee have greater roles to increase women awareness and organizing in the groups. There has been significantly increased an articulating and bargaining power among the women to claim the rights with duty bearers particularly with Village Development Committees/municipalities and district line agencies. There has been comparatively reduced gender-based violence in the community due to organized women action against discrimination. The work load of the women has been reduced due to access to drinking water; grain mills, road transportation facility and increased gender awareness etc. However, the patriarchal social structure is still dominating in the society. The promoting gender equity and social inclusion in real sense is challenging work for civil society organizations at the community. There is a need of strong lobbying and advocacy work to influence policy, practice, ideas and beliefs at local and national level.

The migration of youth to foreign countries for employment has become a major demographic phenomenon, affecting local level resource management. According to the 2011 census, there were 474,022 absentee people from the TAL districts; Nawalparasi district has the highest absentee population (63,220) and Parsa has the lowest (7,376). Males represent the overwhelming majority of the absentee population, skewing the gender balance in these districts and the TAL as a whole. These factors have forced a change in gender roles, increasing the number of women-headed households and compelling women to take on a greater role in natural resource governance [12].

III.4.1 Before and Now Situation Mapping of Tal and NCPA Program

The score ranking tool was used with the participation of women and men of Buffer Zone Forest Users' Committee in Chitwan to measure the impacts of overall TAL and NCPA at the buffer zone community level. When asked on before and now situation mapping what was the changes observed in the community that the respondents scored the main impacts of programs in plant, people and wildlife using certain impact indicators (Table 5).

A total of 10 seeds of corn (assumed to be 100 per cent) were distributed to the leader of the committee to judge the changes observed in the area. The focus group discussion was conducted that included women and men members of sustainable village in the scoring exercise. Each group member was welcome to participate in the discussion before scoring. There has been overall positive trend happened over the period of time due to the interventions of TAL, SHL and NCPA programs in the buffer zone communities as whole. The overall performance of programs has been increased from 41 per cent to 75 per cent over the period of five years. However, 20 per cent (fifth quintile population) poor and vulnerable families still excluded from the

programs. This situation is similar in Sacred Himalayan Landscape as well as perceived by local people. This is the challenge for the implementing partners. The poverty alleviation is the challenging job for conservation workers. It needs to be focused in the years to come. There is need of special programs and strategy in order to address the need and priorities of ultra poor and vulnerable groups of buffer zone communities [13].

Table 5: Before and Now Situation Mapping of the Biodiversity Conservation Programs.

Program Outputs	Before (August 2012)	Now (June 2017)	Reasons
Terai Arc Landscape			
Sustainable Forest Management	5 (50 %)	7 (70 %)	Plantation and mess wire fencing. Conservation education to community people. Active support of Community forestry Users group. Controlled grazing. Increased people awareness. Used of mobile based technology for monitoring. Distribution of improved cooking stoves. Increased use of gas for cooking purpose.
Species and Ecosystem Conservation	4 (40 %)	8 (80 %)	Increased no. of wildlife population due to increased real time monitoring using mobile based technology. Increased positive relationship between park and people due to buffer zone program interventions. Mobilization of youths Decreased wildlife poaching etc. Done corridor bottleneck restoration. Organized transboundary meeting between China and Nepal and Nepal and India.
Climate Change and Energy	3 (30 %)	7 (70 %)	Increased use of biogas and solar power Use of spring water for irrigation and drinking purpose. Increased pond water collection for irrigation.
Freshwater	3 (30 %)	8 (80 %)	River cleaning and protection of water source. Increased access to drinking water, sanitation and hygiene practice.
Churia Watershed Conservation	5 (50 %)	8 (80 %)	Controlled grazing and illegal logging harvesting. Increased awareness among the people to conserve Churia watershed.
Sustainable Livelihoods	5 (50 %)	8 (80 %)	Increased income of the buffer zone people due to NTFP based small enterprises, formation of agriculture cooperatives, ecotourism, commercial vegetable farming, fishery farming, dairy enterprises, skilled-based training etc.
Policy and Advocacy	3 (30 %)	5 (50 %)	Lobbying and advocacy works to protect national park and rights of the buffer zone community. Engaged in policy and strategies formulation with Government of Nepal and others. Local leadership development. Increased use of government budget by buffer zone people.
Planning, Monitoring and Development	4 (40 %)	8 (80 %)	Increased participatory planning and learning process.
Conservation Education and Capacity Building	4 (40 %)	8 (80 %)	Increased people's awareness through conservation education and capacity development of local institutions/cooperatives. Organized trainings and educational tour to local people.
Changes in lives of local People	5 (50 %)	8 (80 %)	Level of direct poverty and injustice among the poor people has been reduced because of integrated nature of program interventions, lobbying & advocacy works with Government of Nepal, political parties and donors.
Total Score	**41**	**75**	Satisfactory result
Average Score	**4.1 (41 %)**	**7.5 (75 %)**	**Satisfactory performance observed**

Source: Author, (2017).

Note:

Rating Score: satisfactory, 3-4 moderately satisfactory and 1-2 unsatisfactory.

Species Conservation:

Conservation of tiger, rhinoceros, gharial crocodile and vultures has a priority for interventions. Status and trends of major species are summarized below:

Tiger: A target to double the adult tiger population in TAL-Nepal by 2022 was set during this period as Nepal's commitment to the global tiger conservation goal. Between 2011 and 2014 the tiger numbers in TAL-Nepal protected areas increased by over 60%, to 198 adult animals, and Nepal is on track to achieve the 2022 target of at least 250 adult tigers managed in meta-populations in the landscape [14].

Rhinoceros: The rhino population increased to 645 animals in 2015 from a low of 372 in 2005 during a period of intense poaching. Functionality of the Khata corridor is being confirmed by tracking movement of satellite-collared rhinos to India's Katarniaghat WS.

Gharial: Over 800 captive bred gharials have been released into the Narayani, Rapti, Karnali, Babai and Koshi River systems to augment wild populations. A survey in 2013 estimated the wild gharial population at 124 animals, which is a 21% increased since the previous count in 2008. Evidently most of the gharials released move downriver and across the barrages along the Nepal-India border (or are washed down during floods), but survive in India, contributing to the populations in the TAL rivers, albeit in India.

With recovering wildlife populations, an increase in human-wildlife conflict has been inevitable. Most conflicts in the TAL occur with elephant, rhino, tiger, leopard, sloth bear, wild boar and ungulates. A range of mitigation measures (such as solar power fences, deep trenches, viewing towers and cultivation of

unpalatable crops) have been employed to reduce conflict, with mixed results. Programs to establish community-based anti-poaching units (CBAPUs), Eco-Clubs, citizen scientists, and other education and awareness programs have been successful. Provision for relief funds at community level has been piloted aiming at quick response [15]. DNPWC (2017) has stated that the active participation of citizen scientists in monitoring snow leopards and local people's involvement in community based anti-poaching operations have become a successful model for community empowerment [16].

There has been challenged faced by the Program Management Team due to the Gorkha earthquake of 25 April 2015 and its aftershocks resulted in huge loss of life, injury, and economic damage in 31 districts (Central and Western Regions) of Nepal, affecting all sectors. NPC (2015) has stated that the post disaster needs assessment (PDNA) estimated the value of damage and loss at $7,065 million, a large proportion of it housing [17]. While reconstruction will take many years and more investment, there is a great opportunity to ensure that building back is not only 'better and safer' but also greener, ensuring healthy ecosystems for disaster risk reduction and natural resources for resilient livelihoods and economic prosperity [18].

III.5 GAPS

The following gaps have been identified to have larger impacts in forest, wildlife, and marginalized people:

• Weak horizontal and vertical inter-sectoral coordination, leading to land use conflicts in case of TAL.

• Concentration of program and project activities in some areas resulting in geographic imbalance.

• The ultra-poor particularly landless and marginalized groups of people still excluded from the mainstream development process.

• Weak integration of climate change that resulted negative impacts in life and livelihoods of the people, plants and wildlife.

• Insufficient integration of conservation friendly infrastructures that restricted the free mobility of wildlife from one place to another.

• Weak governance in addressing forest and protected areas encroachment that there has not been effective anti-poaching campaign and illegal logging particularly in Terai Arc Landscape and Sacred Himalayan Landscape.

• Inability to up-scale livelihood options such as ecotourism and green enterprises in different part of the TAL, SHL and NCPA.

III.6 LESSONS LEARNT

The following lessons learnt have been drawn during the study:

• Forest and wildlife conservation program should go together for species and ecological sustainability. However, local people should be in the centre of biodiversity conservation.

• Plant, animal and human inter-relationship is important factor for the ecosystem/ecological sustainability.

• Commitment to action of Forest Care Takers (Ban Heralu) has remained praiseworthy in order to conserve the forest and wildlife with small incentives. The mobile based technology has become instrumental to increase their efficiency in terms of forest patrolling to control illegal activities works.

• The ecotourism activities particularly the homestay has become the means of income generation of the local indigenous people. This is the good linkage between biodiversity conservation and economic development. The local people have realized that wildlife and forest are the good source of income through ecotourism. Now, the local indigenous people have established love and affection with wildlife, forest and river.

• Regular trainings, review and reflections workshops and positive response from project staff is needed for the capacity development of Ban Heralu, community based anti-poaching unit, rapid response team members, youths in order to boost the morale for biodiversity conservation.

• The sustainability is only possible where there is link the biodiversity conservation works with livelihoods of indigenous people. The forest and wildlife are closely linked with local people's livelihoods. So, we could not undermine the local people in order to forest and wildlife conservation.

• The mobilization of local youths (women and men) for the conservation of forest and wildlife is instrumental. There is need of linkage between self-employment generation of youths and biodiversity conservation works in order to sustain the species and ecosystem.

• The biodiversity conservation work is the fun rather than burden to the state, community and professionals. People can enjoy in biodiversity conservation works.

• People, plant and wildlife should live together with co-existence and they should love each other if there is no threat for their life, livelihoods and habitat. People, plants and wildlife are the creation of Mother Nature. The conservation workers always should think as integrated approach not in isolation.

IV. CONCLUSIONS

The biodiversity conservation work is instrumental for ecological sustainability. The large majority of the respondents (98.63 %) have found happy towards the programs due to getting direct benefits from the buffer zone programs. However, it is yet to be strong enough and large coverage to make a difference in the life of poor and marginalized people. There have been a still 20 per cent ultra poor people excluded from the benefit sharing of mainstream development process. In the areas, the participation of women in the development process has increased particularly in decision-making process at households, community and municipal level. Most of the natural grasslands in Terai have now been converted for housing and agriculture farming. Many grassland patches in protected areas are being encroached by woody perennials in the absence of the annual monsoon floods that set back natural succession and maintain grasslands. However, There has been increased tiger and rhino population and community based conservation work has enhanced in the last couple of years. The satellite radio monitoring of snow leopard has been carried out and established Gaurishankar Conservation Area are regarded as significant work supported. In case of Sacred Himalayan Landscape, conservation work together with local communities is facilitated, wildlife crime control unit was established, and capacity building of government staff and local communities has been enhanced. In the program areas, human-wildlife conflict, wildlife crime and encroachment of forest areas are the challenges faced by the implementing agencies. The community-based monitoring system particularly in wildlife poaching control, control illegal logging, and marketing of non-timber forest products based enterprises need to be strengthening. However, the biodiversity conservation work is challenging and time consuming. There is a need of linkage, coordination, collaboration with stakeholders

and integrated approach to develop relationship between people, plant and wildlife species.

V. AUTHOR'S CONTRIBUTION

Author contributed solely all part of the article.

Conceptualization: Nar Bikram Thapa
Methodology: Nar Bikram Thapa
Investigation: Nar Bikram Thapa
Discussion of results: Nar Bikram Thapa
Writing – Review and Editing: Nar Bikram Thapa
Supervision: Nar Bikram Thapa
Approval of the final text: Nar Bikram Thapa

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RESEARCH ARTICLE OPEN ACCESS

ADDITION OF HIGH ESTERIFICATION PECTIN AS A STABILIZER IN THE PRODUCTION OF LOW FAT YOGURT

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ABSTRACT

A shake-type low-fat yogurt prepared with highly esterified pectin extracted from valence orange by acid hydrolysis with conventional heating was evaluated. A completely randomized design was used with experimental and commercial pectin (0.15, 0.3, 0.45%), and a control. Cow's milk was adjusted to 1.5% fat, with skimmed milk powder and pasteurization at 85ºC, 30 min and sucralose and lyophilized lactic culture were added with stirring, until acidity 0.58% and pH 4.74. Pectin was added as a stabilizer and subsequent refrigeration and storage at 5ºC ± 1ºC. Acidity, pH, syneresis and viscosity were evaluated for 28 days and sensory analysis by seven trained judges (NTC 4129), ten days after the yogurt was elaborated, using discriminatory test of multiple comparisons. The highest acidity and syneresis was found in the control and the two pectins (commercial and experimental) behave the same at equal percentages. Treatment with 0.15% and 0.3% of experimental pectin show a color close to the control and show slight statistical differences between them. Yogurt with less than 0.3% pectin presents an identical flavor to the commercial one and higher ones present differences with the control and affect the final flavor of the product. Yogurt with 0.3% experimental pectin presents a body without lumps, without syneresis, firm and smooth consistency, maintains the characteristic smell, aroma and flavor and meets the requirements of the NTC 805 standard, with a maximum of 0.5% fat, minimum of 2.6 % protein and 0.6% acidity with a shelf life of 22 days.

I. INTRODUCTION

Over the shelf life of a yogurt or fermented milk, pH decreases over time and acidity increases, due to the action of the initiating culture Streptococcus thermophillus and Lactobacillus bulgaricus, which cause lactic acid fermentation in milk by the enzymatic hydrolysis of lactose in glucose and gactose, with glucose subsequently decomposed in lactic acid [1]. This decrease in pH occurs not only during incubation, but also during yogurt storage, because microorganisms become viable, although the decline is less marked due to the effect of low temperature. The lactic acid produced gives a refreshing acidic flavor, while the compounds carbonyls, acetaldehyde, acetone and diacetyl (produced during fermentation) provide the product with the characteristic aroma and flavor [2].

Normally, exudate increases with storage time, for this reason the addition of Pectin, especially low esterification has the tendency to bind the water embedded in the structure of the gel improving the hydration of proteins and preventing the secretion of water from the structure, finding less serum loss, better firmness, good rheology, quality and taste to yogurt low in fat, increasing the content of soluble solids, a lower pH and lower serum loss [3].

The structure of pectin, in particular the degree of esterification, defines many of its physical and/or chemical properties. In a commercial pectin extracted from citrus fruits, with a esterification grade of 70-74%, the length of blocks of free

carboxylic groups can vary from molecule to molecule, and each pectin molecule normally includes several blocks of different lengths. Useful pectin as a stabilizer of an acidified milk drink, at least some of its free carboxyl groups must be arranged in blocks (i.e. contiguously), and not randomly distributed discreetly along the polymer chain [4].

The basic structure of pectin consists of four types of polymers: a linear chain of methylsterified galacturonic acid called homogalacturone I (HGI), a branched region with ramnose attached to arabines or galactose called (RGI); a linear region of galacturonic acid bound to xylose (XGA) and a last branched region whose galacturonic acids are attached to different types of monosaccharides such as apiosa, fucose, glucuronic acid, ramnosa [5].

An acidified milk drink requires adequate viscosity; when there is an excess of pectin, there is the undesirable effect of causing significant increases in viscosity, reaching to gelling extremes. Maintaining a narrow working range is commercially difficult, because insufficient pectin produces sedimentation or excess causes undesirable high viscosity [6].

Concentrations of 0.1 - 0.2% genu pectin improved the rheological, chemical and sensory yogurt properties of Semi-skimmed yogurt [7-8]. A concentration of 0.3% ospino ñame starch and 0.6% ITAL 1000Y pectin as stabilizer in the production of beaten yogurt, increased viscosity during storage without affecting the rheological behavior characteristic of yogurt or its physical-chemical and sensory characteristics [6].

The effect of the use of potato, sweet potato and corn starch on the rheological and textural properties of denatted yogurt was evaluated, finding that 1% starch could significantly reduce syneresis and improve the firmness of yogurt [9]; and with 15% aloe vera and 5% granadilla, having less exudate due to aloe vera [10], and adding whey protein was obtained a difference in viscosity with a yogurt control [11].

The effect of yellow peach flour (INIAP-Quillu) was evaluated at 0.3%; 0.6%, and 0.9% on the physicochemical and rheological properties of low-fat yogurt, finding that the most accepted yogurt was yogurt with 0.9% flour, observing an increase in viscosity with 15% aloe vera and 5% granadilla, having less exudate due to aloe vera [10], and adding whey protein was obtained a difference in viscosity with a yogurt control [12].

Polymerized whey protein (PWP) obtained from cheese whey was evaluated on the physicochemical, texture, microstructure and sensory properties of low-fat curdled yogurt, finding that texture, apparent viscosity and sensory properties are similar to witness [13].

The objective of this work was to extract valencia orange peel pectin (Citrus sinensis L. Osbeck) by chemical method, identify neutral sugars and pectin structure and establish the optimal percentage of this high esterification pectin as stabilizer in the production of low-fat yogurt.

II. MATERIALS AND METHODS

Pectin was obtained in batch reactor with hot acid solution using the method described by [14]. 10 g of dried orange skin collected in "Nueva Esperanza" farm (flat coordinates: N 1008903 – W1524140) of the municipality of Chimichagua (Cesar), was treated with 100 mL of water (1:10) and heated to 80°C by 10 min for enzyme inactivation. The pH of the liquid was adjusted to 2.0 with HCl (0.5 M), and the suspension was heated to 90°C with magnetic agitation at 200 rpm for 1h. The suspension was then repeatedly filtered and washed with acidified water. Pectin was precipitated with aqueous ethanol solution 96% at 1:1 ratio and stored for 2 h, then filtered and washed with ethanol at 70% and 96%, sedated at 40°C, weighed and milled [15].

Pectin was characterized by determining the degree of esterification [16] y Galacturonic acid (m-hydroxydiphenyl colorimetric method). For the composition of neutral and acidic sugars, the sample was drying a test tube, 20 g of inositol was added as a standard reagent; methylglycosides were prepared by methenalysis in HCl (1 M) in methanol at 80°C (18 h), followed by N-acetylation with pyridine and acetic anhydride in methanol. The samples were then per-O-trimethylsililated by treatment with Tri-Sil (Pierce) at 80°C (0.5 h). The analysis was performed by GC/MS in Agilent 6890N GC with interface at 5975B MSD, using an Agilent DB-1 capillary column of 30 m x 0.25 mm ID silica [17]. For molecular weight determination, a solution of 2 mg.mL-1 of the sample, was passed through a spin filter at 0.45 m, followed by injection of 100 L into the HPLC. Exclusion size chromatography was performed on Agilent 1100 HPLC with Superose 12 column with 50 mM ammonium acetate eluent, flow rate of 0.9 mL.min-1 and ELSD detector (Detector Scatering Light Evaporative). Molecular weight fractions were determined from retention times, elution volume, and peak width and height. These tests were performed at the Complex Carbohydrate Research Center lab at the University of Georgia in the USA.

II.1 PREPARATION OF LOW-FAT YOGURT

A completely random design was used with seven treatments, three with pectin extracted from orange peels (T1, T2 and T3) and three with commercial pectin at concentrations of 0.15, 0.3, 0.45 % (T4, T5 and T6) and a treatment without addition of pectin (T7) as a reference (witness), with variance analysis (Anova) and mean comparison test by the Tukey method, at 95% confidence. Fresh cow's milk with less than three hours of milking, filtered and skim was used in a centrifuge with a capacity of 100 L up to a fat percentage of 2%. Fat was adjusted to 1.5%, using 2.96% skim milk powder (Colanta, Medellin, with 0.31% fat) and pasteurized at 85°C and 30 min. Allow to cool to 42°C and add 0.0183% sucralose stirring to dissolve it. The freeze-dried lactic culture of Streptococcus Termophillus and Lactobacillus Bulgaricus was added and stirred constantly during inoculation to an acidity of 0.58% lactic acid and pH 4.74. After 3 hours and 15 minutes, the temperature decreased to 10°C and stirred vigorously. Pectin is added as a stabilizer at different concentrations. It was packed in pre-sterilized plastic containers, refrigerated and stored at 5°C to 10°C.

II.2 TREATMENT PROPERTIES ON EVALUATION DAYS

Yogurt was evaluated by, acidity (942.05/90 A.O.A.C), pH (10,041/84 A.O.A.C), syneresis (centrifugation, 15 min, 1500 r.p.m.) and viscosity (Ostwald) with three repetitions each week for 28 days and sensory analysis (smell, taste, body, aroma and smell) [18-19] evaluated by seven judges trained according to NTC 4129, was performed ten days after the yogurt had been prepared using a discriminatory test of multiple comparisons with commercial yogurt. The group of tasters were students of the Agroindustrial Engineering program, who were trained to form the sensory panel.

The yogurt corresponding to the desired or optimal was characterized as follows: Fat Content (gerber), Proteins (12.1.07

- A.O.A.C 1984), Total Solids (A.O.A.C 16032, 1984 Modified), Ash (AOAC,2000), Humidity (Method 16.023 - A.O.A.C 1984), Density (Thermo Lactodensimeter), Acidity (Potentiometric Titration), Determination of Theoretical Caloric Content (Relationship), Total Coliform Count and e. coli , Mold and yeast count.

III. RESULTS AND DISCUSSIONS

III.1 OBTAINING AND CHARACTERIZING PECTIN

Table 1: Pectin quality obtained from shells of conventional heating orange.

	Conventional heating	[19]
GaIA (% mol)	44,9	54,4
Ramnose (% mol)	5,8	1,6
Arabinose (% mole)	14,4	13,5
Galactose (% mol)	13,6	3,5
Xylose (% mol)	5,7	0,1
Glucose (% mol)	13,1	2,7
Fucose (% mol)	0,5	n,d
Mannose (% mol)	2,0	n,d
Glucuronic acid (% mol)	n,d,	-
Molecular weight (kDa)	5-10	
Degree of esterification (%)	60,6	65,1
Performance (%)	9,6	27,3

Source: Authors, (2020).

Table 1 shows that pectin contains 44.9% galacturonic acid, lower than obtained by [18] and similar to proposed by [20-21]. The RGI region is approximately 33.8 (ramnosa, arabinosa and gactose) and is within the range of 20-35% raised by [22] et al, 2006. In RGII, glucose predominates, followed by groping and fucosa with about 15.6%. The xylose content (XGA region) has a close value of 5.7. This means that in the pectin found, the HG region predominates, followed by RGI and then by RGII similar to what other authors reported by [23-24]. This pectin is high esterification (60.6%) indicating a low effect of the hydrolysis reaction with short chains (low molecular weight) indicating that perhaps the effect on glycoside joints or β- elimination predominates [25].

III.2 YOGURT PROPERTIES IN DIFFERENT TREATMENTS

In Figure 1, pH and acidity behavior is observed during the 28 days of evaluation, a decrease in pH to 4.3 (a) is observed, with the exception of pectin-free treatment (witness), which is below 4.3. In the same way the acidity increases over the course of days (b), being significantly different its value to the witness (above 1.2%) where other treatments are between 0.8 and 1% lactic acid.

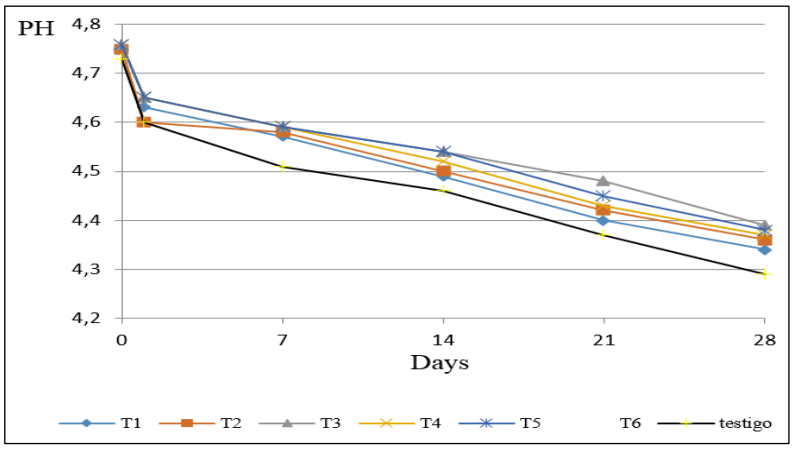

Figure 1: Behavior of pH and acidity during the evaluation days.
Source: Authors, (2020).

The witness was acidified before 14 days and is above the optimal acidity of 0.9% lactic acid [2] (experimental pectin) is acidified from day 21, the other formulations with pectin (commercial or experimental) are within the mentioned value (b).

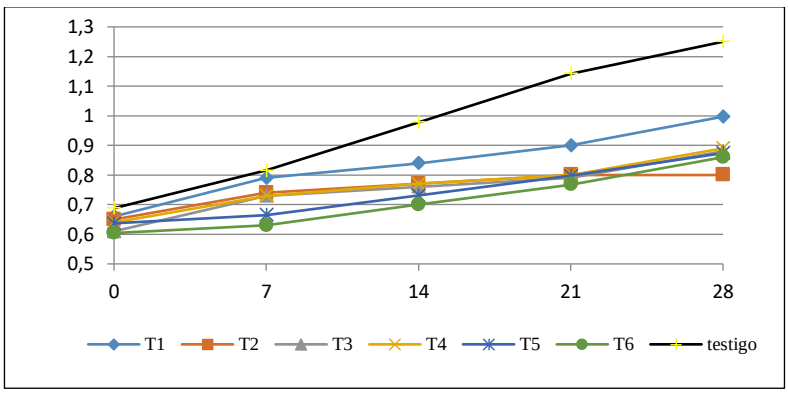

Figure 2: Behavior of exudation during the evaluation days.
Source: Authors, (2020).

Figure 2 shows that commercial pectin at high concentration is the least exudate (T6) and similar behavior presents experimental pectin (T3) up to 21 days. T2 (0.3% experimental) and T5 (0.3% commercial) exhibit the same behavior over time reaching 3.4%. T1 has a higher exudate than other treatments (up to 4.6%) which is lower than that found by [6], with ITAL 1000Y pectin for whole natural yogurt (6,472-1.05%). The witness exceeds the above values with a value of 7.8% water.

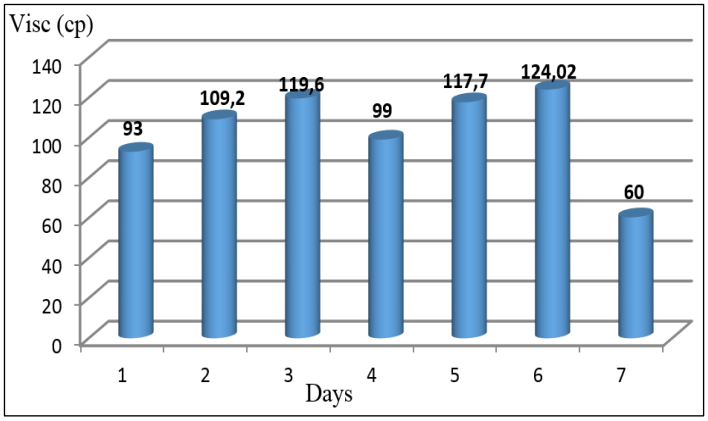

Figure 3: Viscosity behavior after 10 days of evaluation.
Source: Authors, (2020).

The addition of pectin increases the viscosity of yogurt formulations. A higher concentration of pectin (extracted and commercial) give greater viscosity (Figure 3). Generally speaking, the two pectins behave equal to equal percentages. There is only substantial difference with the witness, who shows pectin's work as a stabilizer and the identical behavior of experimental pectin with commercial pectin.

III.3 SENSORY ANALYSIS

Table 2: Comparison of averages of sensory attributes between treatments.

Attribute	T1	T2	T3	T4	T5	T6	Tes
Colour	$5,6^{a}\pm0,8$	$4,9^{ab}\pm0,9$	$4,0^{b}\pm0,6$	$4,4^{b}\pm0,7$	$4,4^{b}\pm0,13$	$4,3^{b}\pm0,5$	5
smell	$4,7^{a}\pm0,5$	$2,9^{c}\pm0,7$	$1,6^{d}\pm0,5$	$4,7^{a}\pm0,5$	$3,9^{b}\pm0,7$	$3,3^{bc}\pm0,9$	5
flavor	$4,7^{ab}\pm0,4$	$4,6^{ab}\pm0,5$	$3,7^{c}\pm0,8$	$5,0^{a}\pm0,0$	$4,4^{ab}\pm0,53$	$4,1^{bc}\pm0,7$	5
Texture	$5,6^{d}\pm0,5$	$6,6^{C}\pm0,5$	$7,7^{b}\pm0,9$	$6,7^{b}\pm0,4$	7,9±0,38	$8,7^{a}\pm0,6$	5
Odor	$5,4^{c}\pm0,5$ $1,0^{ab}\pm0,1$	$6,6^{b}\pm0,5$ $1,0^{ab}\pm0,1$	$7,3^{a}\pm0,5$ $1,0^{ab}\pm0,1$	$5,4^{c}\pm0,5$ $1,0^{ab}\pm0,1$	$6,1^{b}\pm0,4$ $1,0^{b}\pm0,1$	$6,6^{b}\pm0,5$ $1,0^{a}\pm0.1$	5

Source: Authors, (2020).

Equal letters do not present significant differences at 95% confidence.

Treatment T1 with 0.15% and T2 with 0.3% experimental pectin, show a color closer to the Characteristic White Color in the Witness Sample and present light statistical differences between them and very different with the other treatments (Table 2). By increasing the % of pectin, the aroma weakens compared to the commercial yogurt sample, because pectin transfers its orange aroma to yogurt. The T3 treatment has the lowest acceptance value, since apparently percentages of 0.45% change the characteristic aroma of yogurt and with the lowest values in both pectins (commercial and experimental) the aroma is perceived very little and is quite close to the value of the witness and are statistically the same.

Only the T4 treatment has identical flavor with commercial yogurt and other treatments with low pectin content have slight significant differences with commercial yogurt and between them. Pectin values greater than 0.3% in both pectins (commercial and experimental) have substantial differences with the witness and affect the final taste of the product, the T3 treatment being more evident.

In terms of texture, all treatments have significant differences between them and are superior to the witness with a Homogeneous Body, without lumps, without separation of the serum and firm and smooth consistency characteristic of yogurt. This is best evidenced at high percentages of pectins. Treatments closest to the witness with respect to odor are those that contain the least amount of pectin and there are no significant differences between them. Increasing the pectin content makes the orange odor more present, being greater than percentages of 0.45. This can be masked with aromas and fruit content or flavorings.

Treatment 2 was chosen with 0.3% experimental pectin as the ideal for yogurt preparation because it has good stability (viscosity, and syneresis) without significantly altering the organoleptic characteristics of it, contrary to the found by fathia, 2017, that used 0.6% commercial pectin. Generally speaking, T3 (0.45% pectin) did better in terms of pectin stabilizer function, but organoleptic characteristics of the product (smell, aroma and taste) are altered and T1 (0.15%) didn't showed different significant results with respect to the witness.

Table 3: Characterization Yogurt produced with experimental pectin.

Properties	Result	Y/N	NTC standard		Resolution 2310 of 1986	
			Min	Max	Min	Max
Content	1.5%	Y	>0.5%	<2.5%	1.5%	2.4%
Protein	2.7%	Y	Min=2.6 Max= --		not specified	
Total Solids	10.05%	--	not specified		not specified	
Ashes	0.94%	--	not specified		not specified	
Humidity	89.5%	--	not specified		not specified	
Density	1034 g/cm³	--	not specified		not specified	
Acidity	0.772% Lactic acid	Y	Min=0.6% A. L		(0.70-1.50)% A. L	
Total Coliform Count	4 x 10^{1} NMP/ml	Y	(10-100) NPM/ml		(20-93) NPM/ml	
E. coli count	<1 x 10^{1} NMP/ml	Y	0		<3	
Mold and yeast count	10 x 10^{1} NMP/ml		(200-500) NPM/ml		(200-500) NPM/ml	

Source: Authors, (2020).

S = Compliance with requirements.
N = Non-compliance with the requirements.

Yogurt prepared with selected experimental pectin (T2) contains 96% skim milk, 2.96% skim milk powder, 0.3% experimental pectin, 3% Cultivation, 0.0183% Sucralose and was evaluated and compared with NTC 805 and resolution 2310 of 1986 (Ministrio de Protección Social, 1987), which shows that it meets all properties (Table 3). The period of study of the product was 28 days, however the shelf life of the product was 22 days since after this period of time it has undesirable organoleptic characteristics, such as strong acid odor [26].

Based on the content of commercial yogurt properties and developed with experimental pectin, the caloric content was

determined, demonstrating that has 60% decrease in calorie content, more than 50% decrease in fat content and more than 70% decrease in total carbohydrates compared to commercial whole yogurt with very close levels of proteins, being the 107.2 calorie, caloric content for commercial yogurt versus 43.94 for low-fat yogurt in this study.

IV. CONCLUSIONS

Pectin obtained from orange peels and extracted by conventional heating with HCL, is high methoxyl, with properties to be used as a stabilizer to produce low-fat yogurt type beaten (ligth) at a concentration of 0.3%, a shelf life of 21 days and a low percentage of exudate.

V. AUTHOR'S CONTRIBUTION

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Methodology: Ricardo Durán, Carlos Guillen and Juana Bermúdez.
Investigation: Ricardo Durán, Carlos Guillen and Juana Bermúdez.
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RESEARCH ARTICLE OPEN ACCESS

INGUIA: AN INCENTIVE TO THE TOURISM DEVELOPMENT IN MANAUS WITH A DIGITAL PLATFORM SUPPORTS

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ABSTRACT

Brazil offers to the national and international tourists a wide range of options, being the natural areas, the most popular tourist product, a combination of ecotourism with recreation, sun and beach tourism, adventure tourism, and historic cultural tourism. Creating richness and growing the consumption and production of the area. Tourism has great meaning to a city like Manaus, who still shows potential problems to your utilization, among them is mentioned the lack of disclosure, precarious infrastructure, security problems, and the missing of qualification guides to prest assistance to the city visitors. It is Presented the platform and previous results, (InGuia) who can contribute to the problem resolution on finding specialized professionals to prest guide service in the local tours and provides rich and trust information, all completed and updated about all the tourism richness of a place all of this in several languages, which is extremely important knowing how is the variety of nationalities that visit Brazil. Since Manaus Tourism has great potential, with a huge variety of places to visit, we present how Manaus loses all this potential with a bad experience given to the tourist caused by the missing of defined and actualized information. Besides that, it is also difficult for the ones who work directly with tourism, as in the case of the Guides, who suffer to create contact with the tourist. InGuia comes as a purpose to solve these problems, given to the tourist the opportunity to know better the place where he goes to visit, bringing precise information, easy to understand, and easy access. In addition to creating opportunities for Guides to reposition themselves in the market, allowing a better view of the service he proposes. In that way, InGuia helps both tourists who wish to have a better tourist experience, traveling with more convenience and practicality, now that they know they can easily find the information they need, as well as supporting the Guides, allowing the easy exposure of their services.

I. INTRODUCTION

Brazil offers national and international tourists a wide range of options, with natural areas being the most popular tourist product, a combination of ecotourism with leisure and recreation, mainly sun and beach and adventure tourism, as well as historical and cultural. Which in turn generates wealth, increasing consumption, and production due to the new needs for products and services created by tourism [1].

Much of the problem of having more guides on the market is due to the difficulty of finding an agency to associate and provide their services, even though it is an autonomous profession, tourists feel more secure by hiring guides linked to regularized local tourism companies. Such guides must be prepared to offer good experience for those who buy their services, within this experience is the need to speak a common language for tourists.

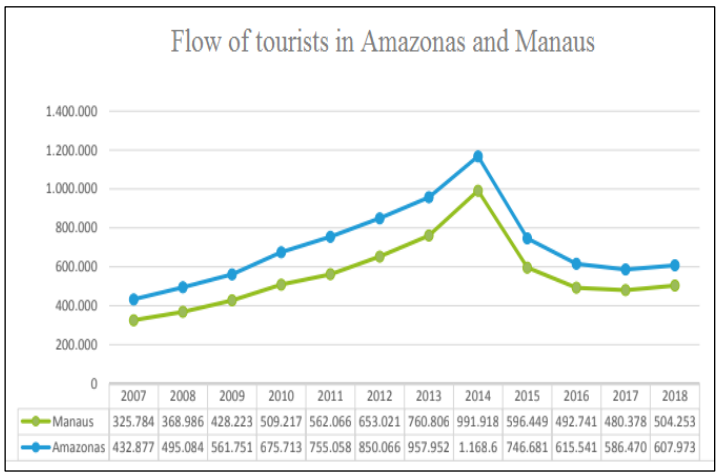
And an area with as much potential as Manaus presents specific problems for its use, among them are the lack of

dissemination, precarious infrastructure, security, and the lack of qualified guides to provide assistance to visitors to our city [2].

Between January and May of 2019, the capital of Amazonas received 285,304 tourists. According to data from the Amazonas State Tourism Company (AMAZONASTUR), the number is 3.32% higher than that recorded in 2018, when it reached 216,123 thousand. Of this total, the share of foreign tourists rose from 102,084 to 106,340 visitors this year - representing a growth of 4.16% [3].

Among national tourists, there was also an increase. While 2019 registered 164,150 Brazilians passing through Manaus, 2018 had 160,610. The number represents an increase of 2.14% [4].

The graph in figure 1 shows the quantitative behavior of the number of tourist visitors in the city of Manaus and in the Amazon.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Manaus	325.784	368.986	428.223	509.217	562.066	653.021	760.806	991.918	596.449	492.741	480.378	504.253
Amazonas	432.877	495.084	561.751	675.713	755.058	850.066	957.952	1.168.6	746.681	615.541	586.470	607.973

Figure 1: Flow of tourists in Amazonas and Manaus.
Source: [4].

Among the concerns presented in the monthly report on the survey of the behavior of tourism in the metropolitan region of Manaus, carried out by the Fecomércio Institute for Business Research of Amazonas (IFPEAM) in March 2019, are the precariousness of the infrastructure and the poor disclosure of the city both in Brazil and abroad.

Tourism in Brazil is a growing and fundamental sector for the economy of several regions of the country. Brazil received 6 million foreign tourists in 2013 and about 6.62 million in 2018, being classified, in terms of international tourist arrivals, as the main destination in South America and the second in Latin America, after Mexico [5].

This article presents the development of a multiplatform tool (InGuia) that can contribute to the problem of finding specialized professionals to provide a guide service on local tours and also provide reliable, up-to-date and complete information on all the tourist wealth of a given location, making them available in several languages, with an auxiliary and interactive map that guides the tourist in his needs as a visitor, making available all varieties of routes, making a marketplace for establishments and everything the tourist needs to know for his safety.

Since applications have been the main development tools in various areas of the world, such as urban mobility, financial needs, language translation, and several other points, InGuia has been proposing a new way of accessing various tools that enable a tourist experience a pleasant place by means of geolocation maps, access to comments from other tourists about the places that are visited and a bank of qualified guides that can be chosen according to the needs that the user seeks to support.

II. THEORETICAL REFERENCE

II.1 TOURISM AND THE NEW WORLD TREND

Tourists use the Internet in all the processes of a trip for different reasons, namely: seeking knowledge about the place to be visited, ease, novelty, creativity, pleasure, and social activities [6].

Through studies carried out by [7], smartphones have changed the behavior and emotional state of tourists by providing and accessing various tourist information quickly and easily. In this sense, the instant information provided by these devices allows the tourist to be more effective in solving problems, sharing, and storing the tourist experience and memory.

It is important to highlight that accessing and sharing information via the Internet, through comments, videos, and photos, has been empowering tourist consumers, to the point that they have been making decisions in planning destinations and tourist activities, without the need for travel agencies [8]. Thus, satisfaction with this information induces different results, such as visiting the destination, quality experience, and high overall satisfaction. Therefore, the mediation mechanism in the context of tourism requires a deeper understanding of the relationship between information needs, information tools (ie the Internet and Smartphones), and the tourist experience itself.

Due to the growing demand for users of mobile applications, websites are adapting their content for this type of platform. These tools are used to strengthen communication with real and potential tourists through information from users capable of influencing decision making [7].

The use of smartphones during the trip is of great interest and relevance, as the human being's search for quick answers in the globalized world has led to the development of tools that make life easier and automate tasks and processes. In this context, the use of this device allows the satisfaction of the tourist's wishes to be immediately sought for an answer to their needs, looking for information, a restaurant, or an event.

In 2017, researchers [8] in their article "Mobile Applications and Tourism: A Quantitative Study Applying the Theory of Planned Behavior", claim that tourism is an area of constant transformation that easily adapts to changes in the market due to its wide capacity for interaction. The incorporation of applications that have destination information, transportation, food, and lodging services within the reach of its users is an aspect to be explored by enterprises and places that have the practice of tourism as a resource for social and economic development.

According to [9], the tourism sector is a major incorporator of technology in its various segments, and its growth always depends on the capacity for innovation and the use of technology to improve management, develop new products, improve communication, optimize travel experiences and personification of service.

II.1.1 REGIONAL TOURISM AND ITS ISSUES

With the main tourist reference to nature, attracting the most different visitors, the tourist activity gained other dimensions, with several branches or denominations, such as rural tourism, ecotourism, nature tourism, adventure tourism, scientific tourism, among other modalities. Among these, scientific tourism is one of the most recent, understood as "the type of tourism made up of people who move with the object of self-education or improve their personal horizon through participation in events or visits to environments of high tourist and cultural value [10].

But the lack of disclosure means that tourists arriving in the city, the tourist routes they take are very limited, leaving aside important aspects of Amazonian culture and history that would be very well seen by those who are attracted by the local beauties. Managers and other operators of the hotel chain in Manaus also made it difficult to attract tourists due to the absence of cultural and business events and the airport infrastructure [11].

In 2014 at the World Cup, Manaus had only 67 regularized tourist guides, according to the State Tourism Company (AMAZONASTUR). And it shows how the city is deficient in regularizing this class and in including these professionals in the job market. Although the profession is autonomous, according to Federal Law 8623/93, the professional must be registered with the Ministry of Tourism and carry the license issued by the Ministry of Tourism, through AMAZONASTUR. In 2020, with the new registration system for tourism providers, cadastur 3.0 implemented in 2018, surveys showed a total of 1,450 tourism service providers regularized at the Ministry of Tourism, an 8.53% increase in the volume of regularized providers if compared to the same period in 2019, which held 1,336 registered developments [12].

II.2 API RESTFUL

API (Application Programming Interface) is a set of patterns that are established in a Z application, so that other applications can use the features provided by the Z Application, without having to access the details of implementation, but only to an interface with which you can interact with it.

In the 2000s, one of the main authors of the HTTP protocol, Roy Fielding, suggested the creation of new HTTP methods, in order to facilitate the semantics when HTTP requests were made. Making it possible, by reading the method, to get a sense of what that request will do, the most used methods are, GET, which means 'to get', that is, when you request data from the application, PUT, is used to update an existing data, POST, is used to create a new data and DELETE, is used to delete data.

REST (Representational State Transfer), is an abstraction of WEB architecture, consisting of a set of rules, and principles that allow the creation of a well-defined API using correctly the HTTP methods mentioned above. And finally a RESTFUL API, which is nothing more than an API that follows REST patterns, that is, when an application correctly uses the REST architecture, this application is considered RESTFUL [13].

II.3 TYPESCRIPT

Typescript is an evolution of the already consolidated JavaScript programming language, basically Typescript is a ‘superset’ of JavaScript typing that is compiled for JavaScript itself. Developed by MICROSOFT, and led by Anders Hejlsberg, it first appeared on October 1, 2012, Typescript is completely Open-Source, allowing anyone to read and contribute to its source code.

The language shares the same basic types as JavaScript, such as String, Number, bool, with the addition of a few more, such as Turple, Void and Any. Its biggest difference and evolution in relation to JavaScript is giving the developer the ability to declare typing, making it easier to understand what types that parameter receives, and what type will be the return of a function, thus facilitating team work, and helping to avoid errors in the development environment [14].

II.4 NESTJS

NestJS, is a Framework for developing efficient and scalable applications focused on the server-side with NodeJS. It uses progressive JavaScript, and is built with full support for TypeScript, (still allowing developers to use pure JavaScript) and combining elements of Object Oriented Programming, Functional Programming and Reactive Functional Programming.

Below the scenes, Nest uses a robust framework for servers like Express (standard) but can also be configured to use Fastfy. Nest provides a level of abstraction above the common Frameworks for NodeJS (Express/Fastify), as well as exposing its APIs directly to the developer. This allows the developer to have the freedom to use third-party modules that are available for the underlying platform [15].

II.5 MYSQL

MySQL is a relational database management system, it is open source, and is used in most free applications to manage databases. This system uses SQL (Structure Query Language - Structured Query Language), which is the most used language for inserting, removing and managing content stored in a database [16].

II.6 AI - CONTENT-BASED FILTERING

Recommendation engines have the function of recommending services or products to people. In a way, recommendation systems tend to limit people's choice by presenting them with suggestions for something they like or would buy. Many companies currently use a recommendation system to help the user discover new content, names like Youtube and Netflix, are already well established in the market in this regard [17].

The main goal of a recommendation system is to increase sales for a particular company. And to make this happen a recommendation system should only make available significant items to the user, [17], in his book on recommendation systems, summarizes the objectives of this system in four points, Relevance, Novelty, Chance and Diversity, is the union of these items that creates a good recommendation system.

After research, it was concluded that the best methodology for this project is Content Based Filtering [18]. This methodology is based on the similarity between the items, so it is based on the principle that the user tends to like an item that has shown interest previously. This type of filtering is very well applied in texts, since the content is described with keywords, that is, it analyzes similar terms already sought by the user to make a more assertive recommendation.

This approach has the advantage of not requiring other users to make recommendations, so a new user may already have personalized recommendations for him. It also facilitates the easy recommendation of new content, since when registering it, the keywords will already be clarified, and the new content can already be indicated to users, this methodology also facilitates the explanation for the user why he is receiving this particular recommendation , thus making it a better experience for it.

II.7 REACT

React is a JavaScript library for creating user interfaces, React is based on 3 (three) central pillars, the first pillar being declaratively, React makes the creation of user interfaces an easy

task. By updating and rendering only the necessary components as the data changes, then declarative Views make the code more predictable and easier to debug.

The second pillar is componentization, allowing the developer to create encapsulated components that manage their own states, so with the combination of these components it is possible to create complex interfaces. And the last pillar, which serves more as a philosophy is, 'Learn once, use anywhere', React is a very flexible library, allowing its easy integration with any other existing technology, thus not limiting the developer with fixed Technologies [19].

II.8 FLUTTER

Flutter is a set of user interfaces made by Google, for creating beautiful and natively compiled applications for, mobile, web and desktop, from a single source code. Flutter is based on Widgets, which are a huge variety of components that make up the user interface, with Widgets it is possible to develop everything within the application, user lists, animations, stylization, interaction with the user, among others [20].

Flutter is compiled directly into Arm Native, using the GPU, and being able to directly access the APIs of the platform and services, so the built application has an almost native performance, being very fast, and making the most of what the platform can offer, being mobile, web or desktop.

III. METHODOLOGY

For the development of a multiplatform system, which aims to serve as an intermediary between tourist guides and tourists, we followed some necessary and recommended steps to have a good idea base.

A bank of guides was created based on the tourism guides registered first with the State Union of Tourist Guides of Amazonas, all of which are analyzed according to the legislation, **General Tourism Law 11.771/08, of September 17, 2008**, this means, the credentials, history, faculty, among other sieves were checked, together with the class regulating body, AMAZONASTUR, to decide which people will offer their services through the platform.

Three initial language alternatives were defined (English, Spanish and Portuguese) so that regardless of nationality, the user experience with the platform will be comfortable and understandable. Users will immediately see the language options that are available on the platform when opening the app, if you set it to English for example, all navigation elements and automatic messages that will appear within the app, regardless of their content, will be in English. An application with different languages is important for a platform that aims to win tourists around the world.

To support and validate the project, a research was conducted with the target audience, following the steps of raising hypotheses, creating a persona that represents our target audience, in order to develop a research that statistically proves that the idea meets the needs of national tourists and local guides. The survey was conducted through formalized questionnaires on google forms and received around 900 responses of great value to the project, which helped to prove the problems faced by tourists on their travels. Interviews were also conducted through phone calls and videoconferencing with the president of the State Union of Tourist Guides of Amazonas, Ananias Correia and with blogger Jô Viajou, Jordana Cavalcante, to talk about the problems faced by tourism guides and discuss how our platform can boost class and regional tourism. with this it is possible to better understand the functioning of this sector and with that the project will have a solid base for its development.

For the development of this project it was decided to use the RESTFUL API concept, that is, the project was divided into 3 (three) parts, the Backend, which will be responsible for the business rules, connection with the database , emailing, and authentication, this backend API will be 'consumed' by Frontend, which will be a Web application, where users interact with an application, and this API will also be used by APP Mobile, this type of architecture is extremely versatile and with better maintenance, since all applications are eliminated from each other, so in the following paragraphs it will be described as tools used in each application, starting with the Backend and moving to the Frontend and ending with Mobile.

The language chosen for use in the Backend was Typescript, as it brings more speed and facilitates team development. To make the execution of the language, the NodeJS platform will be used, which is an asynchronous JavaScript interpreter, to assist in this, the NestJS Framework, it allows the use of the most used architectural model currently, making the scale project in a reliable and organized manner.

The MySQL relational database will be used for data storage, a secure and very fast database management system. In order to connect the bank to NestJS, TypeORM will be used, this is responsible for allowing queries with Typescript, that is, it can translate Typescript to SQL, which is the language understood by most databases data, using the ORM concept, helps the developer to stay focused on a single language, in the Typescript case, as well as organize the source code of the application.

To give a better user experience, a Recommendation System will be used. The idea is that when registering, the user will answer some questions, giving indications of the tourism categories he is most interested in, so initially he can make some personalized recommendations for each user. However, depending on the use, the application will gather more data of the user based on their visits, research and viewing time in certain categories or subjects, so the more the user uses the platform, the more apt the Artificial Intelligence will be to make more assertive recommendations.

Going to Frontend, it was decided to use React, as it also allows the use of Typescript, thus allowing the reuse of knowledge, React is a library widely used in the market, being maintained by Facebook, and with a large community, having a vast amount of tools, it is a library that is constantly growing.

The Mobile application was built with the aid of Flutter, Flutter is a Framework developed by Google that allows the creation of apps for Android and IOS with only a programming language, because it is an interface kit it also facilitated the development of the design , animations among others, thus improving the user experience with the application. A Google Maps API will be used to create the interactive map for tourists, in addition to a payment processor, to allow the purchase of packages and the hiring of Guides.

We opted to centralize the entire project around a language, so that concepts could be reused, and also streamline the maintenance and updating of the code. And these are the main tools that make up ***InGuia.***

The idea is that, if the tourist opens the application and having already registered, have quick access to information regarding the tourist spots, hotels and establishments, the tourist will also have access to a catalog of guides, categorized by types of routes, or the languages that the guide masters.

The guide, on the other hand, would have the ability to make himself available and can be contacted by tourists who might be interested in his service, the application will provide through an API, the guide's ability to send and receive messages to the tourist, through the application itself.

IV. RESULTS, SCREENS AND FEATURES

Usability tests were carried out with 10 users, among them Tourism students, professionals in the field of tourism and tour guides, in addition to tourists who were visiting the city of Manaus.

The usability test is a qualitative test that shows how people interact with the application, during interactions users reported what they were thinking and asked questions about the tools presented on the platform.

Professionals in the sector highlighted that it is a necessary application for tourism and for the state, with emphasis on information and dissemination of tourist points, as they recognize that the system used by tourism agencies does not meet the needs of tourists and does not pay attention to disclosure. of its historical points for the residents of Manaus. In Figure 2-3 a user is observed using the platform in the usability test.

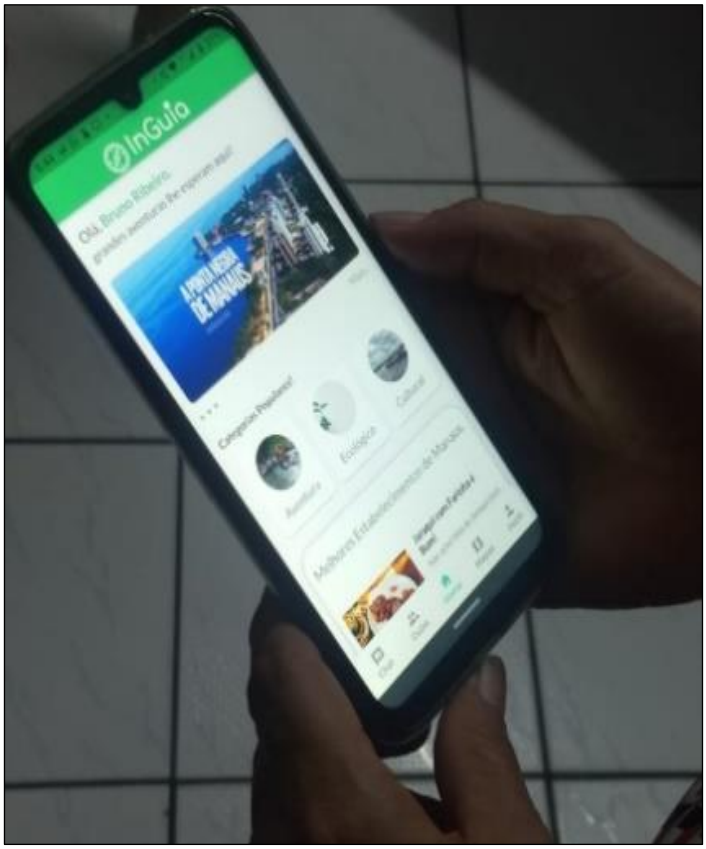


Figure 2: Usability test, home.
Source: Authors, (2020).

It also called attention to the inclusion and opportunities of qualified and regularized tour guides to be able to advertise and publicize their services, since the class suffers a certain neglect caused by the informality of some professionals and the lack of a platform to help in the professional's personal marketing , making an effort to promote itself through customer recommendations.

Tourists were asked to evaluate the interfaces and usability of the tools. the feedback was very positive, they evaluated the interfaces as clean and easy to understand and use even though they were the first contact with the tool.

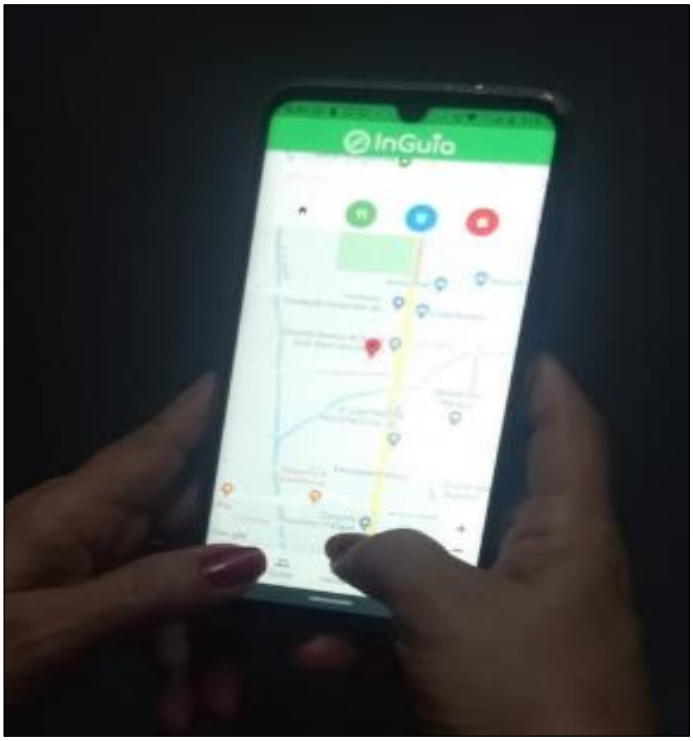


Figure 3: Usability test maps.
Source: Authors, (2020).

The part of the map and the divisions of types of tourism was highlighted by the majority as very interesting because it highlights the tourism segments present in the region and helps in the dissemination and arouses public interest.

As can be seen, the results of the tests carried out were positive and extremely important for the project, in addition to giving tips to complement the platform to better meet the needs of users.

To illustrate the screens, present in the mobile application, some wireframes of them were attached. Figure 4 shows the login screens and the registration screen in case there is no registration on the platform.

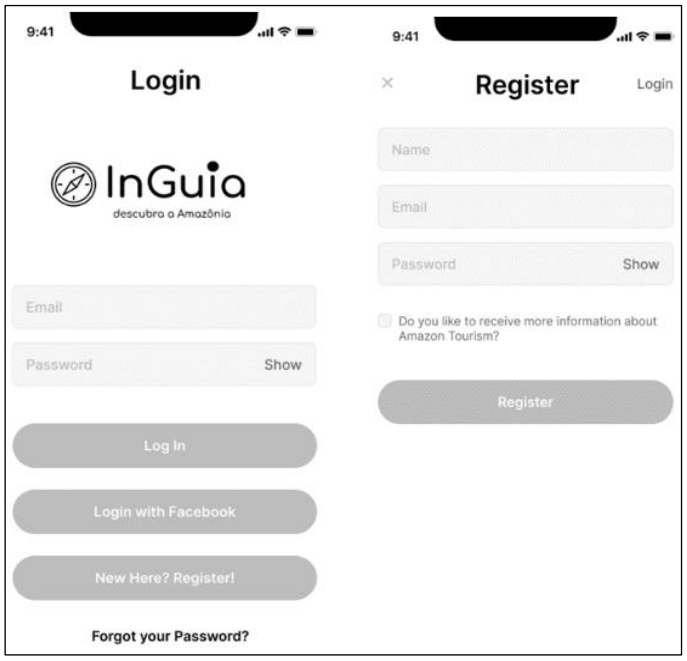


Figure 4: Login and Registration screens.
Source: Authors, (2020).

Figure 5-6 shows screens such as the home screen, where the highlights of the local tourism, the tours, the best-rated tourist spots and the services offered by tourism agencies and tour guides, the product screen with details and observations and the cart that is where the tourist will pay the requested products.

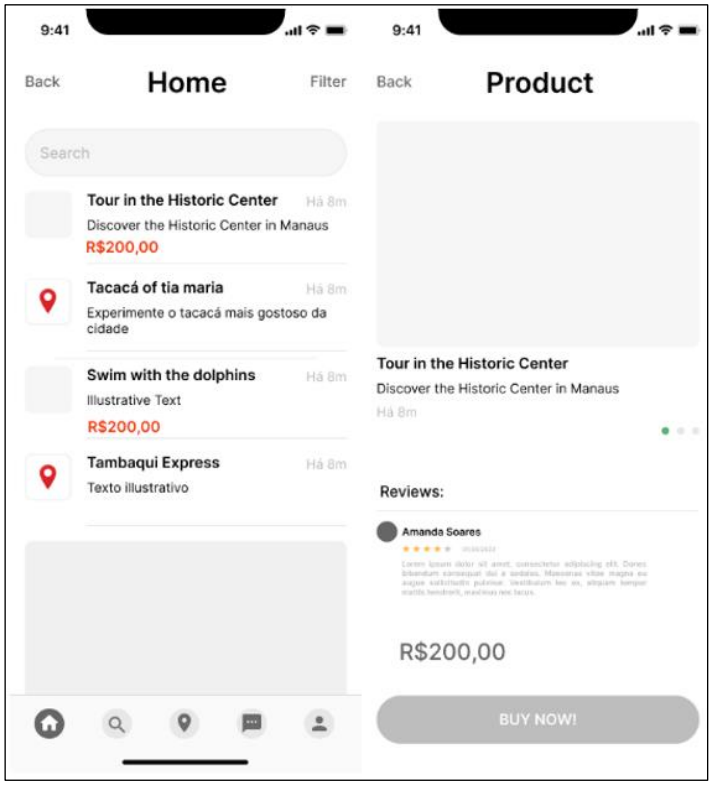


Figure 5: Home screens and product details and purchase.
Source: Authors, (2020).

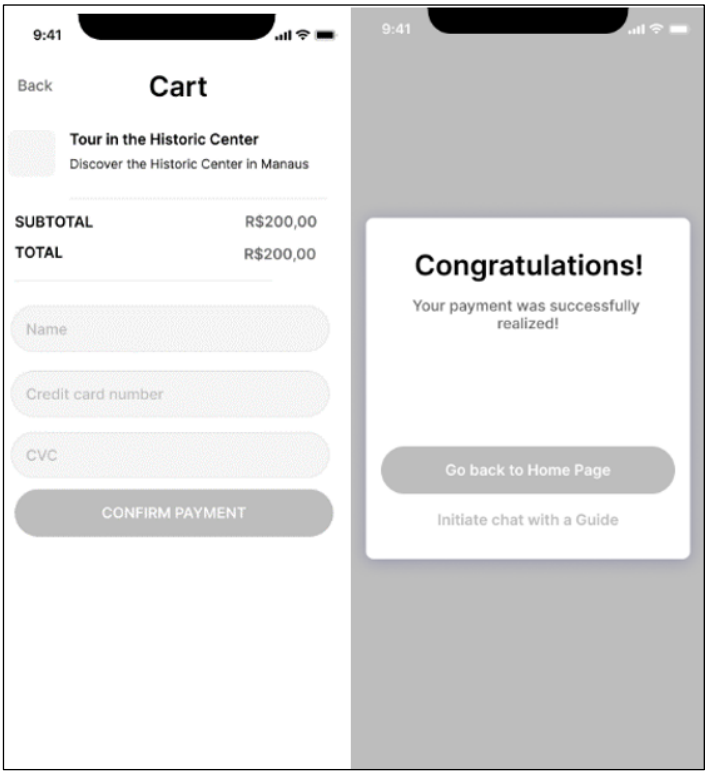


Figure 6: Home screens and product details and purchase completion.
Source: Authors, (2020).

Figure 7 shows the Map with information focused for a tourist, a cleaner map in order to assist the visitor when he is in the city. This map also includes the marketplace of partner establishments.

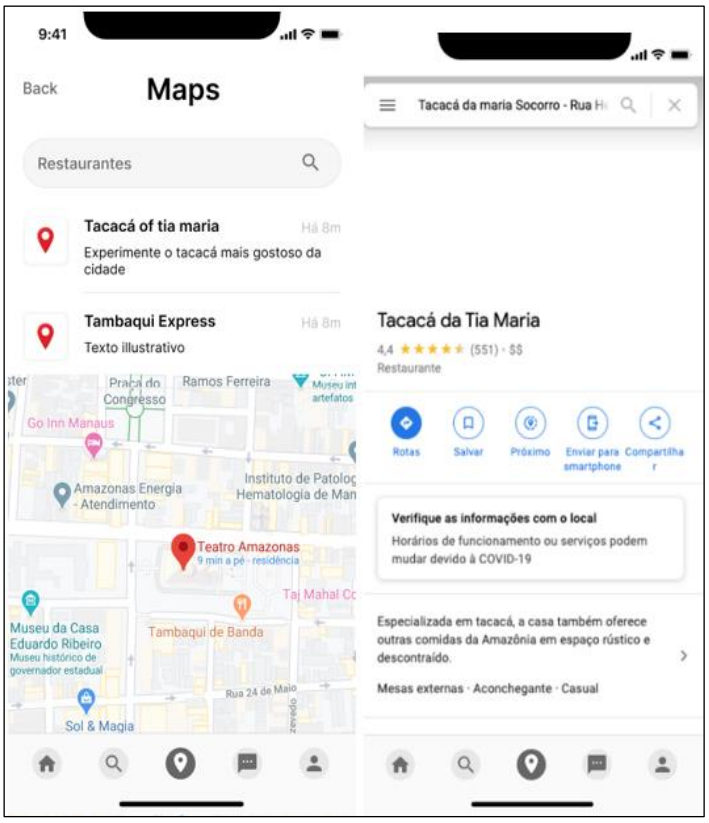


Figure 7: Map and Marketplace of tourist points.
Source: Authors, (2020).

Figure 8 depicts the screens containing the Cards of the guides with evaluations and details of his work, such as the tour specialties he offers and the 'chat' being made available by the application itself, to facilitate communication between tourist-guides. If the tourist has a preference for language or category of tour he can facilitate the search through filters that will be made available.

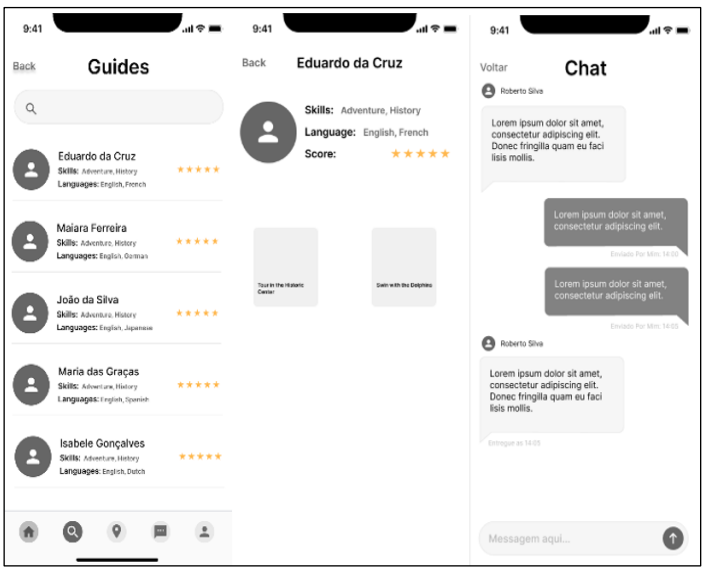


Figure 8: Search screens for tour guides, details and chat.
Source: Authors, (2020).

Figure 9 shows the screens where the guides will have access to the ads linked to them and have control over the comments and evaluations of their customers and view their finances within the platform. The guides registered their skills and the tours they will offer, within the APP, setting the price and offering additional services such as transportation, food, number of hours that will be dedicated to the tour and etc. each guide must report the languages he is fluent in, which type of tourism he is most qualified, such as historical tourism, gastronomic tourism, cultural tourism, adventure tourism, among others, to facilitate the service contract according to his expertise.

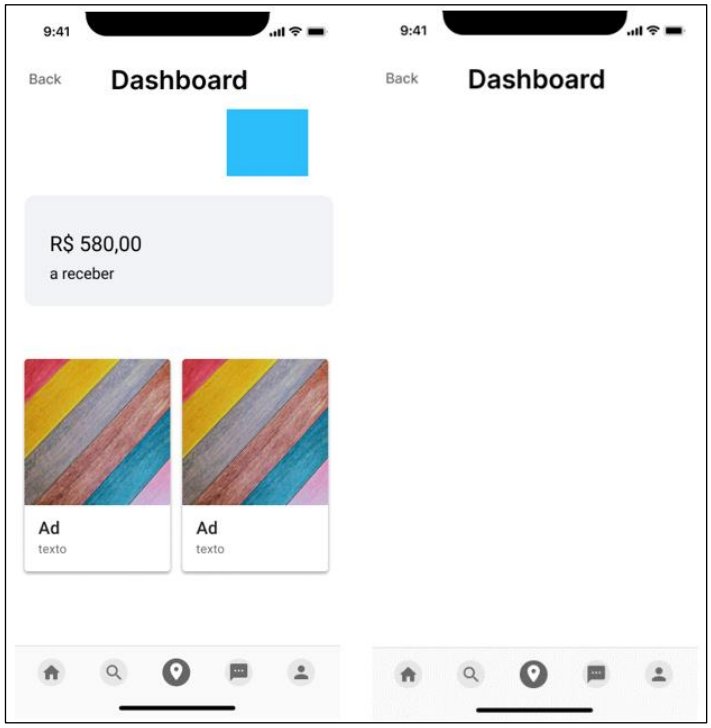


Figure 9: Login and Registration screens.
Source: Authors, (2020).

V. CONCLUSIONS

In this article, the problem of tourism in Manaus is presented, with a huge potential for tourism, and with a huge variety of places to visit, it shows the bad experience given to the tourist due to the lack of well-defined and updated information. Other than that, there is also a difficulty for those who work directly related to tourism, as in the case of Guides who suffer to create contact with the tourist.

InGuia comes as a proposal to solve these problems, giving tourists the opportunity to get to know the city they are going to visit better, bringing accurate information, easy to understand, and easy access. In addition to creating opportunities for Guides to reposition themselves in the market, allowing a better view of the service he proposes.

So **InGuia**, helps both tourists who want to have a better tourist experience, traveling with more convenience and practicality, now that they know they can easily find the information they need, as well as supporting the Guides, allowing the easy exposure of their services.

As previously mentioned, an API REST approach was used, that is, the backend with business rules and database connection will be in an isolated application and the mobile platform will only consume the information from this backend. The next steps now are, finish the backend and deploy this application on AWS or Digital Ocean, which is a cloud service platform, he will be responsible for maintaining the application online so that the mobile platform can access it from anywhere. After that, the Wireframes presented above with Flutter will be improved, making the connection with the backend API, and finally making the platform available for download in the application stores, both for Android and for IOS.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: João Paulo Reis Marques and Bruno Fabiano Silva Ribeiro.
Methodology: João Paulo Reis Marques and Bruno Fabiano Silva Ribeiro.
Discussion of results: João Paulo Reis Marques, Bruno Fabiano Silva Ribeiro and Manoel Henrique Reis Nascimento.
Writing – Original Draft: João Paulo Reis Marques.
Writing – Review and Editing: João Paulo Reis Marques and Bruno Fabiano Silva Ribeiro.
Resources: Bruno Fabiano Silva Ribeiro.
Supervision: Manoel Henrique Reis Nascimento.
Approval of the final text: Manoel Henrique Reis Nascimento.

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RESEARCH ARTICLE OPEN ACCESS

A PROPOSAL TO DESIGN AND DEVELOP A MICROWAVE WEED CONTROLLER FOR AGRICULTURAL USE

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ABSTRACT

Problems based on agricultural activities are increasingly adversely affecting the environment and living health mostly due to chemical inputs used which cause concerns globally. One of the non-chemical weed control methods is the microwave weed control method. The purpose of this research is to propose an environmentally friendly agricultural machine design that can be an alternative to harmful chemicals used in weed control. In this study, microwave generators (magnetron) receive their energy from a generator fed from the tractor shaft. Multiple magnetrons, control, and leakage unit, and waveguides operating at 2.45 GHz ISM will be used. The design includes a magnetic shunt transformer, a high voltage capacitor, a filter, and a cooling fan with each magnetron where microwave leaks that occur during applications can be controlled and magnetron activities can also be monitored. Field applications and tractor working conditions will be analyzed and the device will be re-designed and developed according to the needs. In this study, unlike the other studies, more than one magnetron will be used and the device is designed for open agricultural areas applications. This design and application area differences are the most important feature that distinguishes this study from others, and it is made for the first time. Its use is expected to occur in all countries with similar characteristics for agricultural production.

I. INTRODUCTION

Environmental, ecological, and agricultural sustainability is one of the most global issues of concern recently especially due to climate change [1]. Agriculture is a strategic sector for all countries to ensure food security of the nations as well as for reasons such as the supply of raw materials to other sectors, rural development, and employment [2]. Globally, there is a decrease in agricultural lands while the population is increasing [3]. This inverse relationship has accelerated the search for higher yields from agricultural unit lands. Therefore, the amount of chemical inputs used in agricultural activities has been increasing day by day at least to meet the food needs of the increasing world population. While the use of artificial inputs in agricultural production causes an increase in productivity in the short term, it may also cause some negative effects on living things, natural resources, and the environment in the medium and long term [4]. Especially in agriculture, the use of uncontrolled artificial inputs has become more widespread with the development of chemical technology, which has become a cause for concern in all aspects as the chemical residual leftovers on the resources and the products [5]. Globally, the level of concern about safe food among the consumers has been increasing due to chemicals with pesticide residues [6].

The known side effects of herbicides include deaths in non-target organisms and long-term effects such as changes in the structure of the ecosystem and the number of species [7]. The adverse effects of herbicides on human health as well as on bees, birds, and fish, microorganisms, and invertebrates are very serious. It is known that it causes cancer in people who are exposed to phenoxy group herbicides, which are widely used worldwide [8-11]. Besides, it has been stated that triazines are associated with breast cancer [12], while terbuthylazine causes lung cancer [13].

The prohibition of chemical substances used in weed control in agricultural production in most of the countries, which are harmful to natural resources, ecology, human and animal health, has increased the scientific studies on non-chemical alternative methods in weed control, especially in developed countries due to many reasons. As a result of the competition between the plant and weeds, significant yield losses may occur in the main crop depending on the weed type. In the fight against weeds, the weeds are generally expected to germinate and then the weed is tried to be destroyed by using chemical or mechanical methods. This situation creates direct costs on agricultural production, natural resources, and the environment arising from agricultural activities. Besides, it causes an indirect cost increase as weeds make it difficult to use machinery during product harvest, blending, and storage.

One of the non-chemical weed control methods is the microwave energy method. Although this method has not reached an economical and applicable level yet, it is a method that has been studied by many researchers. Because it is a more environmentally friendly method compared to chemical control methods. This method is expected to be developed and used widely soon.

The purpose of this research is to propose an environmentally friendly agricultural machine design that can be an alternative to harmful chemicals used in weed control.

II. THEORETICAL BACKGROUND

Electromagnetic waves cover a wide range of frequency or wavelengths and these waves are classified according to their source. Since all electromagnetic waves propagate in space at a speed (c) of $3x10^8$ m/s, between frequency (f) and wavelength (λ); There is a relation in the form of equation (1).

$$\lambda = c / f \quad (1)$$

However, this relation is valid for monochromatic plane waves. Today, microwave ovens for home use operate with a frequency of 2.45 GHz. In devices operating with this frequency, if the wavelength of microwaves λ is about 0.122 m. The solution of the three-dimensional wave equation with the help of boundary conditions gives the standing waves in the x, y, z direction conforming to the following equation (2).

$$\frac{1}{\lambda^2} = \frac{1}{\lambda_x{}^2} + \frac{1}{\lambda_y{}^2} + \frac{1}{\lambda_z{}^2} \quad (2)$$

Assuming microwave propagation in a volume with wavelengths $\lambda_x, \lambda_y \; ve \; \lambda_z$ and linear dimensions $are \; L_x, L_y \; ve \; L_z$.

The basis of microwave heating is to increase the speed of motion of molecules such as water by increasing the frequency and the resulting increase in molecular vibration and collision, and the temperature in the material. Because of this feature of microwaves, the energy of microwaves has been tested in many studies such as in agricultural soil disinfection, restriction of germination of weed seeds, and destruction of germinated weed seeds which are given as follows.

These studies are about, physical disinfection with high-frequency electromagnetic waves [14], [15], microwave energy applying to the plants germinated at 8, and 16 days for different periods [16]. Interest in the effects of electromagnetic waves on biological materials started at the end of the 19th century and most of the studies conducted in this period are related to the effects of Radio Frequencies (RF) on plant seeds [17]. Most of the studies have shown that the cause of living cell deaths is due to microwave thermal effect and microwave electric field [18]. Because, microwave energy is transferred directly to the material through molecular interaction in microwave heating, which is another advantage of microwave heat treatment application [19].

As a result of another study, we can say that disinfecting the soil with microwave heat treatment is an alternative to the chemical control method as it does not leave any chemical waste behind [20–22], which is very important in terms of sustainable use of natural resources. Similar results were also obtained in the study of removing organophosphorus (organic phosphorus) pesticides from the soil with the help of microwaves [23]. Extremely successful results have been obtained in studies of limiting the germination of unwanted plant seeds with microwave energy [24–31]. In most of the studies, although an increase in seed germination was observed in short-term microwave applications, it was found that seeds died in longer-term applications [32].

However, undesirable side effects such as physical damage, non-uniform heat distribution, and deterioration in biological values may occur in agricultural products during microwave drying processes [33]. It was stated that the non-uniform heat distribution of microwave energy used in food heating reduces the heating quality as well as threatens food safety in another study [34]. And the research was concluded that some of the microwaves (thermal losses) produced during weed control applications with microwave energy leak into the external environment and the microwave method increases the energy cost and decreases its competitiveness with chemical methods [35].

III. MATERIALS AND METHODS

Generally, a single magnetron was used in most of the microwave weed control experiments described in the literature. However, it is thought that it will be more effective to use more than one magnetron in the design to be made due to the very low heating effect and the non-uniform heat distribution of microwaves.

In this study, microwave generators (magnetron) will receive their energy from a 30 kVA AC generator (Fig.1) fed from the tractor shaft. 10 standards 700 watts' magnetrons (Fig.2) and 10 waveguides operating at 2.45 GHz ISM will be used in the design. The design includes a magnetic shunt transformer, a high voltage capacitor, a filter, and a cooling fan together with each magnetron.

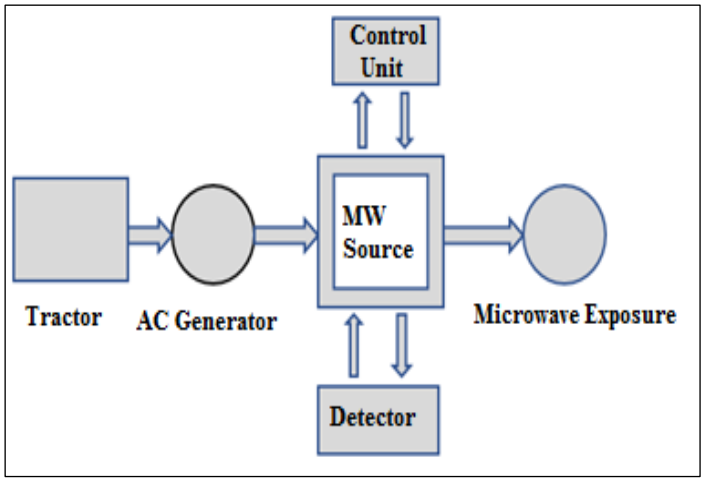

Figure 1: Block diagram of the MW weed controller.
Source: Authors, (2020).

It is very difficult to notice that if one of the magnetrons fails due to any malfunction. Therefore, to eliminate this problem, a monitor will be used to monitoring the operation of each magnetron. Besides, 4 microwave leakage detectors will be used to detect whether microwave leaks that may threaten the health of employees during the implementation exceed the 5 mW/cm² safety limit determined by the FDA (U.S. Food and Drug Administration) and EPA (U.S. Environmental Protection Agency). These detectors have a frequency calibration of 2.45 GHz and a measurement range of 0-9.99 mW/cm^2. Measurement accuracy precision is ± 1 dB and the warning measurement value is 5 mW/cm². Since the distance of microwaves to the target plant will reduce the penetration depth, the device is designed to be adjustable in height according to the target plant height to be applied. Also, to prevent non-uniform heat distribution, which is an important problem in microwave thermal applications, the placement positions of the magnetrons are designed to provide optimum uniformity (Fig.2).

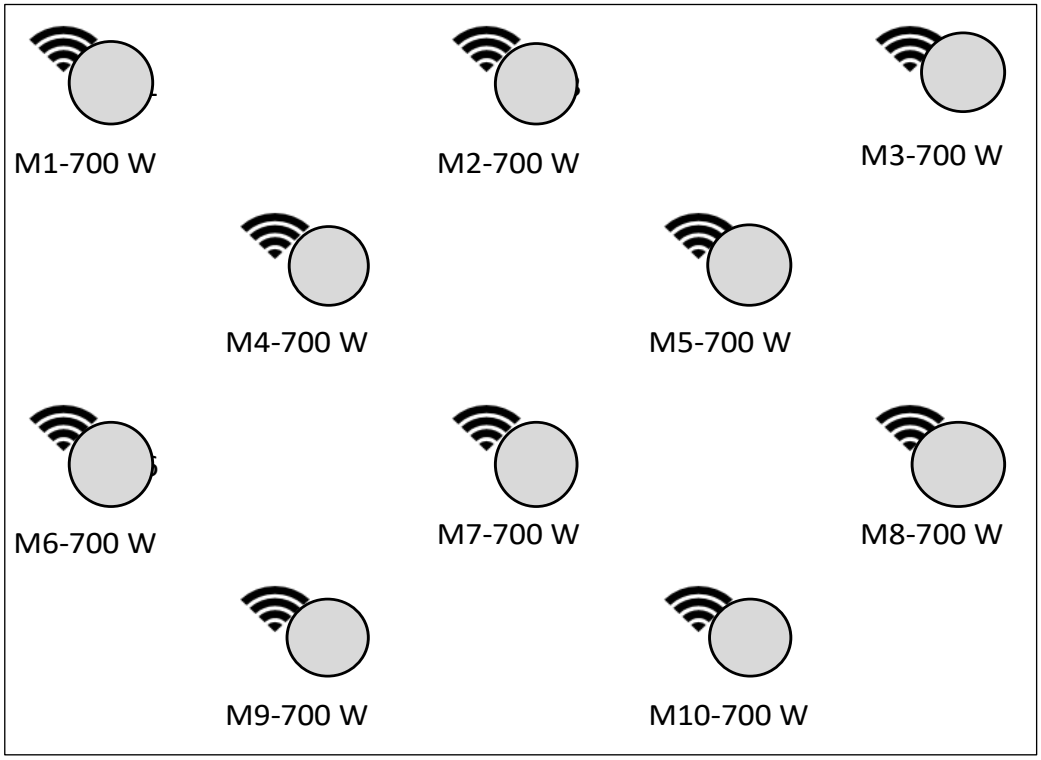

Figure 2: The layout of 10 pcs of 700-watt magnetrons.
Source: Authors, (2020).

IV. RESULTS AND DISCUSSIONS

In most of the studies, the trials have been made in a closed volume with a single magnetron about the use of 2.45 GHz microwaves as a weed control method. In this study, unlike the other studies, more than one magnetron will be used and the device is designed for open agricultural areas applications. This design and application area differences are the most important feature that distinguishes this study from others, and it is made for the first time. This device, which takes the necessary electrical energy from the tractor tail shaft, will feed 10 psc of 700 watts' microwave output power magnetrons and other control units. It can control the detect thermal leaks and operations of magnetrons during microwave applications. The device will be tested on common weeds in the research area, Şanlıurfa, which is located within GAP (The Southeastern Anatolia Project) and necessary improvements will be made according to the results to be obtained. GAP Project is Turkey's largest regional development project based on water and land resources and Şanlıurfa is the most important province in terms of agricultural potential in the GAP project [36], [37].

The efficiency of the device in the field conditions and its compatibility with the tractor will be analyzed after the trials. The device will be re-designed and developed according to the needs if required.

IV.1 HAZARDS AND CONSTRAINTS IN MICROWAVE APPLICATIONS

Every innovation and design has its constraints and risks. During microwave applications, microwave leak detectors are used against microwave leaks. As is known, microwave energy can be absorbed by the body and generate heat in exposed tissues. Weak organs with temperature-sensitive tissue such as the eyes with blood flow and temperature control are more they have a high risk of heat damage.

It is also important to know that microwaves and radiofrequency radiation are non-ionizing radiation and microwaves do not leave any residue on plants, foods, or water [38]. Microwave applications provide the opportunity to deactivate weed seeds in the soil seed bank. However, most of these technologies require medium to high energy investments and, in some cases, involve high risks to human health and safety, such as electric shock or electrostatic fields, which should be considered [39].

Internal friction occurring in the polar environment causes heating in the reaction mixture. However, reflections and refractions that occur at local boundaries cause "hot spots" and "superheating" [40]. This process is usually described by a friction model. The majority of polar materials show dielectric losses in

contact with microwave [41]. One of the main problems with microwave heating is non-uniform heat distribution. Non-uniform heat distribution has been studied by various researchers [42]. Numerical analysis of the electromagnetic field and temperature in a microwave-applied volume and the characteristics of microwave heating have also been studied [43]. Correct determination of energy density or thermal distribution in dielectric heating with microwave provides significant benefits in studies. Microwave heating or drying sometimes leads to poor quality products [44–49]. It has also been shown in studies that low voltage electric current and short-term microwave exposure accelerate the germination of plant seeds [50–53].

What is important in such innovative designs is whether the constraints and risks are manageable. Risks that are expected to arise in both literature studies and this design are acceptable and manageable risks by taking basic precautions.

V. CONCLUSIONS

While the world population is increasing globally, agricultural areas are decreasing. On the other hand, agricultural areas have a sustainability problem. Besides, the negative effects of artificial inputs using agricultural production on ecology and life are increasing. Every design and innovation has its advantages and disadvantages. The important thing is that the advantages are more than disadvantages and the expected problems are manageable. Instead of herbicides with such obvious negative effects, the development of more environmentally friendly alternative methods should be encouraged.

This design will reduce the possible use of chemical herbicides on the environment and living health. With simple basic precautions, possible harmful effects can be prevented during use. On the other hand, this device needs to be tested and developed under field conditions. Although it is a high-cost device under current conditions, it is a fact that this cost will decrease if it is developed and mass production is started. It should not be forgotten that this high cost will be less than the money to be spent on the elimination of environmental problems caused by agricultural activities. This design will be the first in its field. Its use is expected to occur in all countries with similar characteristics for agricultural production. Since this design is in the patent stage, drawings and models are not given here in detail.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Hasan Şahin, Mustafa Hakkı Aydoğdu and Mehmet Reşit Sevinç.
Methodology: Hasan Şahin and Mustafa Hakkı Aydoğdu.
Investigation: Hasan Şahin.
Discussion of results: Hasan Şahin and Mustafa Hakkı Aydoğdu.
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Supervision: Hasan Şahin and Mustafa Hakkı Aydoğdu.
Approval of the final text: Hasan Şahin, Mustafa Hakkı Aydoğdu and Mehmet Reşit Sevinç.

VII. ACKNOWLEDGMENTS

The model design, drawings, dimensions, and concept are not given in detail as the device design is in the patent stage.

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RESEARCH ARTICLE OPEN ACCESS

THE EMERGENCY ARCHITECTURE - REUSE AND RECYCLE MATERIAL AFTER DISASTERS

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ABSTRACT

These research papers aim to explain the methods and joints of design based on the principles of emergency architecture, which focus on its concepts on reusing and recycling local materials after natural or man-made disasters and crises. In a systematic design framework that is limited by many obstacles, such as the shortage and limited availability of low-cost materials, and the lack of local labor experience. To reduce the negative impacts of disasters in developing and displaced countries, we must highlight the importance of alternative materials that can be regenerated (straw and bamboo), recycled materials, Reused materials, semi-finished materials (earth and clay materials).

I. INTRODUCTION

First of all, shelter and settlement are complementary requirements and aim to provide a safe and healthy living environment for groups displaced after crises and disasters when the dimensions of the area are the first measure of distinction between them, the shelter is located on the scale of the area of the house and the settlement is located on a broader scale to include local and civil societies [1].

In fact, within the concept of shelter and settlement, seven basic criteria aim to mitigate the damage; caused by the crisis and saving the affected groups, and include planning the site in general, and then settling in particular, creating a place to live in, providing the family with tools for housing, providing technical assistance, and creating Safe environments and achieve sustainability standards, but we will discuss the technical assistance standard in detail [2].

Essentially, the shelter is one of the basics needs for life requirements with dignity, as defined in Maslow's hierarchy of needs because it includes models of five levels including receiving technical and humanitarian assistance to ensure mitigation of the negative effects of displacement and the enormous pressure on depletion of local resources [3].

On the other hand, to ensure that people get adequate technical assistance, several key measures include understanding site planning and materials available before the crisis, achieving the "community empowerment " sustainability component, expressing their opinion about shelter or settlement design to achieve the greatest degree of psychological or physical comfort and studying the characteristics of sustainable materials locally to achieve the highest possible quality standards and to ensure that the life of the shelter or settlement increases as long as possible [4].

In fact, it includes the innovation of new building methods and practices (resulting from the improvement of previous local techniques) that are commensurate with the crisis; to reduce the future risks of destroyed home structures and create job opportunities for the local population (people who have a high ability to carry out construction activities) under the supervision of skilled and experienced workers in building standards to increase skills technology for them safely, easily, following the bidding and contracting processes approach to achieve the best

possible management of materials, financing, and labor within the regulatory legal requirements [5].

Then, it supported the idea of sustainability through rationalizing the selection of sources of appropriate environmentally friendly building materials (vernacular materials) and fast building (achieving the concept of adaptation) and focusing on local resources at the reasonable and adequate quality and the use of alternative materials unfamiliar to local culture only when necessary for a negative impact at times. This is to support and raise the economy after the crisis [6].

Finally, define procedures that clarify how to maintain and store familiar, locally available tools and materials with multiple and common uses at reasonable prices; to achieve economic and time benefit (speed), to accomplish tasks with high quality and provide the minimum basic needs for shelter, which is to provide a safe living space [7].

II. LITERATURE REVIEW

What are the main factors in choosing recycled materials after local crises and disasters?

The material extraction location must be close to the disaster site, the use of low-cost manufacturing processes, and the organization of construction operations the work is given to men with greater effort and less effort to women, and to choose building materials with high flexibility and resistance to seismic shocks and natural and industrial hazards [8].

The most popular building materials used in recycling operations after natural or man-made disasters and crises are straw, earth materials, bamboo, and adobe. These materials have proven their effectiveness in crisis areas and their high value and low cost, as they are local materials that require local labor [9].

The state of Nebraska, in the United States, is distinguished by the use of straw, as it is the first country to use it. Where they studied its distinctive properties in terms of the ability to compress and form easily, mechanical strength, insulation capacity, cost, and thermal energy, embodied energy, fire resistance, long life, abundance, and ease of construction and transportation to the site. Where the results were curved for these characteristics positive and of a high degree. Although there are negative qualities of straw, such as lack of resistance, weakness due to moisture, and weak water resistance, its advantages outweigh its disadvantages [10].

When straw material is used in construction, it must be dry and free of grains. A thread is used to tie the bales of straw together to firmly fix them when they are placed on top of each other when building. The world's most common straw the load bearing and the in filling, the post and beam system, Energy-building systems (straw insulation), prefabricated construction (straw bale panels) [11].

Table 1: A comparison of the most common straw systems in the world.

	Construction Methods	Material	Cost	Durable	Long life
The load-bearing &the in-filling	**-First:** beam foundation where long wooden stakes are craved in order to stick the first row of bales. **-Second:** the stakes are stick-on the bales from the top **-Third:** the end of the top row، the entire wall must be framed by a top beam which distributes the roof weight evenly and where the roof beams are laid out. **-Forth:** The rows are compressed through several tight straps between both top and below beam	**Wood stakes**	**Low-cost**	**Low**	**Medium**
The post & beam system	**-First**: conventional wood frame structure where the bales are inserted. **-Second:** compress both bales and beams. **-Third:** cover the bales with clay-based plaster or lime، applying multiple layers to it and allow each material to dry up properly. **-Forth:** ensure that the layers are impervious to water but not to water Vapor.	**Wood, clay-plaster& lime**	**Medium cost**	**High**	**Longest**
Energy- building systems	**Non**	**Local bricks**	**High cost**	**High**	**Longest**
Prefabricated construction	**Non**	**Export wood**	**High cost**	**Medium**	**Shortest**

Source: Author, (2020).

Figure 1: Straw- load-bearing and the in filling.
Source: [12].

Figure 2: Straw - The post and beam system.
Source: [12].

Figure 3: Straw - energy upgrading with straw building.
Source: [11].

Figure 4: Straw - prefabrication with straw.
Source: [6].

By comparing the techniques of building straw in Table 1, it was found that the best system for building straw is the post and beam system because it contains clay material that creates a cool indoor air quality in summer and warm in winter, in addition to not containing volatile or carbon materials with a negative impact on health, clay is also characterized by its high ability to absorb unpleasant odors and annoying sound waves from outside and naturally regulate air humidity [13].

Figure 5: Straw - The use of clay material in construction.
Source: Author, (2020).

The best application of sustainability principles and strategies is the use of vernacular (local) materials that are embodied by the use of building materials for the earth, as they are widely available everywhere and have a long life, low cost and can be extracted and converted into a building material easily and without much effort, subject to reuse and recycling permanently, You do not need mechanisms to transport it, as it is located on the site itself [14].

Before starting to use the earth materials, an examination should be carried out. The ground must contain a mixture of sand, silt, and clay, provided that the clay percentage is not less than 17% and not more than 35%. The land that contains a lot of clay or sand must be balanced, adding resources to other locals [15].

Earth materials can be found midway to the hills because the soil contains organic matter in low proportions compared to the valley soil that is full of sediments, also the amount of sand is less compared to the tops of the hills where the percentage of soil erosion is greater, the climate is moderate and suitable, unlike valleys and hills that have strong winds and cold most of the time [16].

Table 2: Explanation of the types of ground construction - the monolithic system, the masonry system, the filling system.

	Type of systems
Monolithic system	• Where earth is rammed (taipa) • Where earth is stacked (cob) • Where earth is modelled (façonnage).
Masonry system	• Pressed blocks (BTC) • Cut blocks (sod) • Cast blocks (adobe)
Filling system	• Earth filling • Taipa filling • Earth roofing

Source: Author, (2020).

The last type of material to be recycled after crises and disasters are construction buildings in Taipa (rammed earth) & Adobe. Earth ramming (Taipa) can be defined as a bearing system that requires strengthening of the structural angle with a system called gigantic. But we have to distinguish between the two materials because most architects believe they are one building material [17].

Summarizing the most prominent differences between the two materials is that adobe is more flexible than taipans, and does not require the consumption or production of heat energy due to its dependence on sunlight for drying. The most prominent similarity and the intersection between the two materials are that both of them require no exposure to rainwater or soil moisture. Also, both are durable, stable, and proven efficient in old and restored buildings [6].

Figure 6: Mosque of Djenné, Mali, Portugal-Manitou Cliff Dwellings national monument, Indians.
Source: [11].

If earth materials are used, they must be mixed with clay mainly, because it contains materials of a high degree of hygroscopicity that work to create a healthy and moderate internal environment, it is preferable to put two layers of clay at least of a thickness of (1-2) cm. Sometimes a layer of small straw fibers is applied to avoid cracking of the final layer of gypsum. Mud has a unique ability to absorb high-frequency electromagnetic waves [18].

Countries with the highest exposure to natural disasters are the ones that most use the principle of recycling building materials, such as Portugal, which suffers from the deterioration of the economic system due to its exposure to seismic shocks, they work to encourage the idea of self-construction for social housing, using local materials with low environmental costs and the least negative impact on the environment. Currently, they support the idea of using bamboo to build strong, resilient structures that resist earthquakes [19].

The most important principle in achieving ideal recycling of materials, especially after disasters, is the participation of the

local community in cooperation with experts to preserve the spirit of the place and address the environmental aspects, without ignoring the functional and social aspects, as it reduces the cost of bringing foreign workers, it works to empower and create a working disk, reduce the unemployment rate and support the economy significantly for the displaced areas [20].

We can summarize the construction steps using recycled materials in displaced and earthquake-prone areas: preparing the necessary techniques and materials, preparing the necessary layers of finishes such as (mud and plaster), the use of different types of sand and long-lasting paint, the use of wooden beams and their fixation by using nails vertically to the sand, the clay layer is painted using linseed paint for its ability to give the surface texture and smoothness, the upper part of the building (the facility) is isolated with mosaics to add an aesthetic character [21].

Practical applications on the use of alternative materials in times of economic crisis or after catastrophic events, which focuses on low-cost low-tech architecture with a social purpose in Haiti's:

In response to Haiti's devastating earthquake in - 2010, Dutch architect Pieter, stoutjesdijk has conceived an emergency architectural shelter that can be assembled from a series of parts in a little under five hours.

Figure 7: Natural disaster area, Haiti's.
Source: [2].

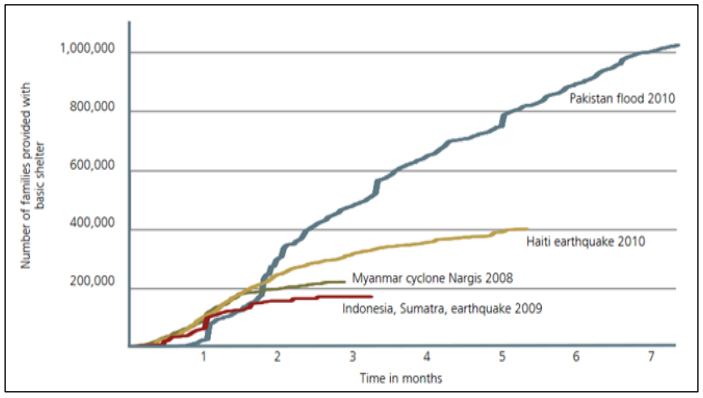

Figure 7: of the distribution against time for major international shelter responses.
Source: Author, (2020).

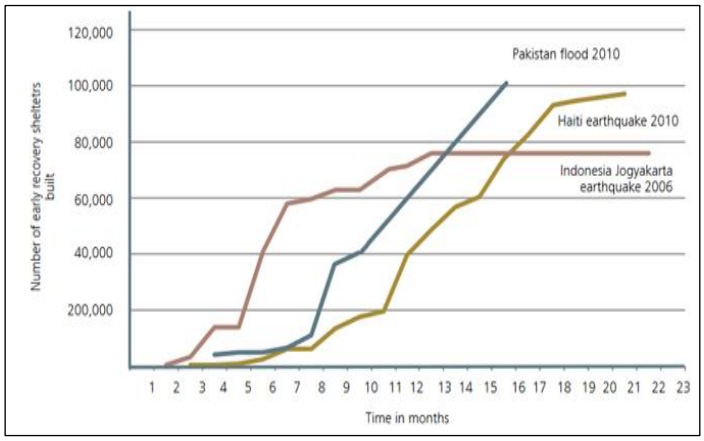

Figure 8: of the number of early recovery shelters built against time for some major international shelter responses.
Source: Author, (2020).

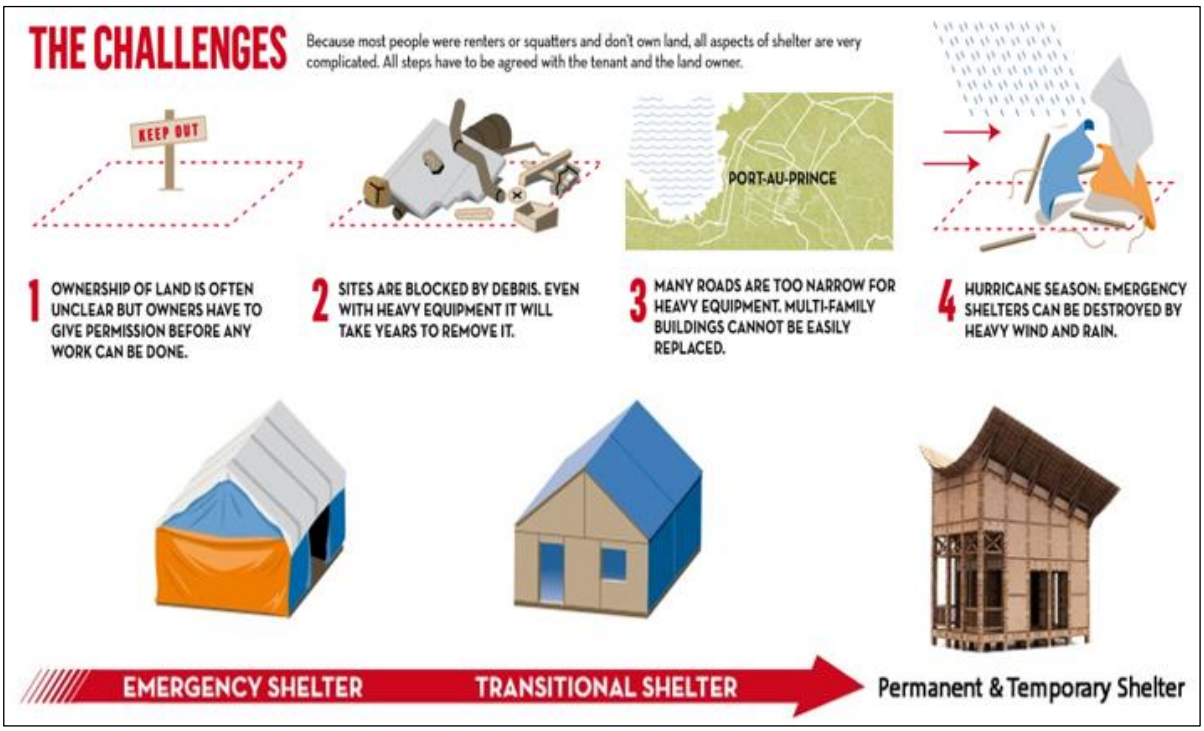

Figure 9: What and how will we face the challenge of devastation after a natural disaster (earthquake?).
Source: Author, (2020).

The thesis of the project (shelter Haiti's) is the Rebirth of the industrial revolution: That mass customization, personalization, and variety can replace 20th-century rigidities of production. Design of the habitat has been suited for the climate and condition of Haiti's tropical temperature (Aesthetic level, Functional level) [22].

The shelter, which can be described as permanent as a result of the January 2010 earthquake, was designed using reused, waterproof wood with nano-coating chemicals, and a local source from Haiti, It takes about 5 hours, the life expectancy is 3-5 years, the construction team is 9 people, the number of buildings is 2000, the approximate cost of materials for each shelter is about 1,560 Swiss francs. The approximate project cost per shelter is around 2,300 Swiss francs, this is the fastest house built in the world [23].

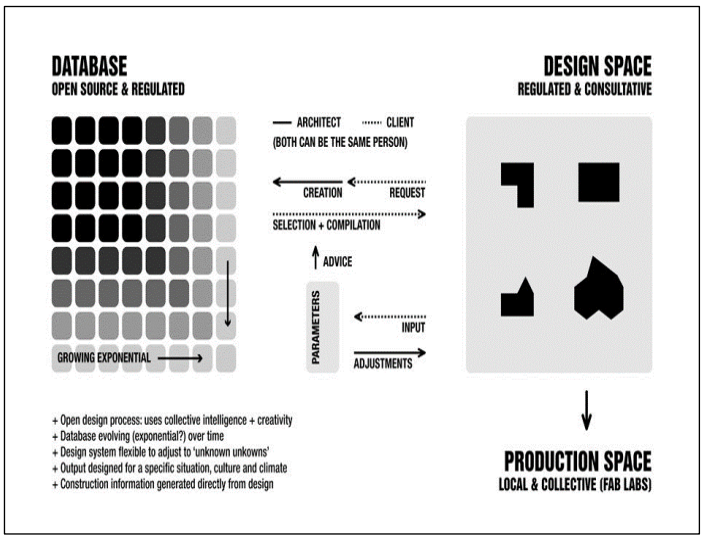

Figure 10: Conceptual Thinking, Haiti's shelter.
Source: [24].

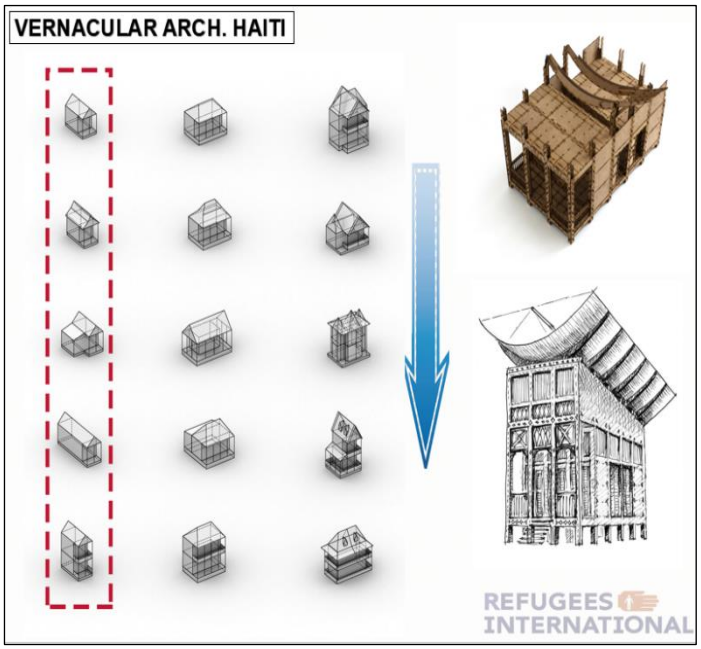

Figure 11: KAY HOUSE, The typology is Kay's houses were formerly used as slave shack and now symbolizes pride and independence, 2-4 rooms long, to be extended at the back; the triangle in the gable roof is a strong symbolic element, originally made from wooden posts and beams with a thatch roof.
Source: [25].

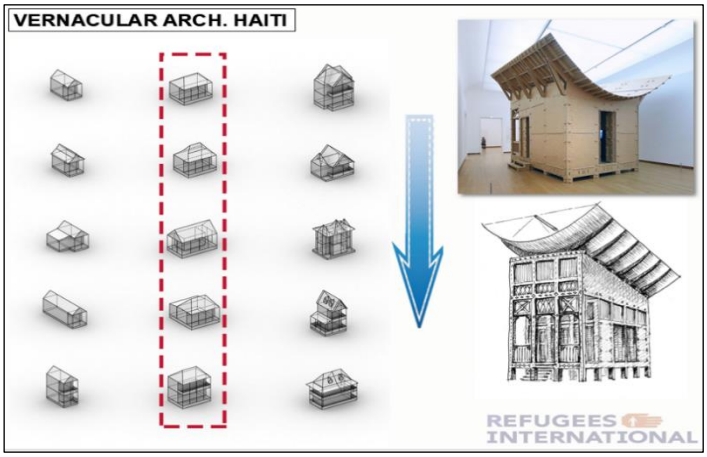

Figure 12: CREOLE HOUS, This type was first used in the late 1700s by Plantation owners and still belongs to the upper class, Characteristic is its overall symmetry and its long porch parallel to the road, The hipped roof is shaped to resist storms, Usually, the floor is raised several feet above the ground.
Source: [25].

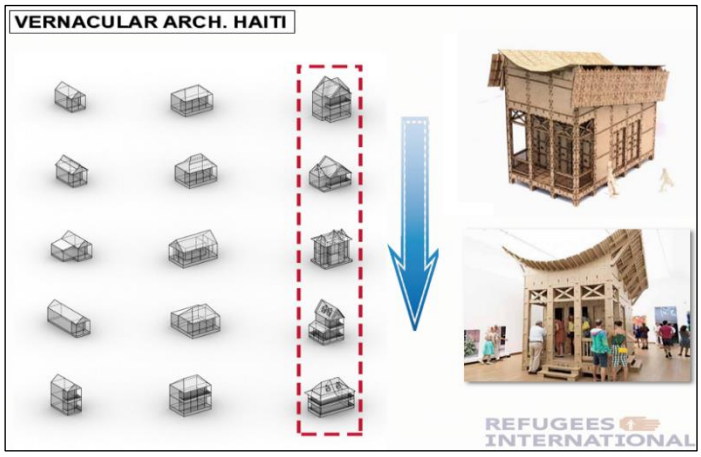

Figure 13: GINGER-BREAD HOUSE, Housing type was introduced in the post-colonial period, Therefore acts as a vital symbol for rebuilding Haiti, Characteristic is its intricate ornament and steeply pitched roofs, The construction of wooden sheets and beams has proved to be seismically resistant's.
Source: [25].

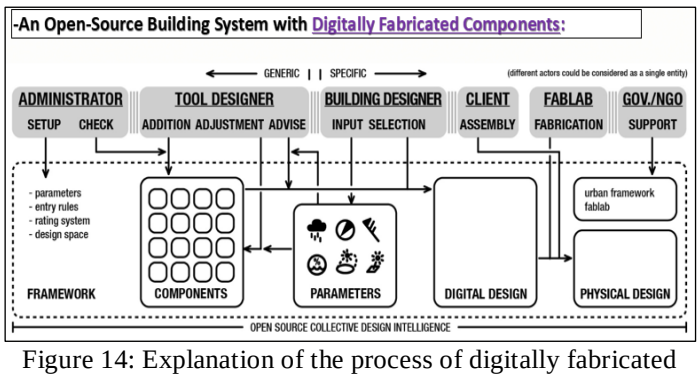

Figure 14: Explanation of the process of digitally fabricated components.
Source: [14].

A design and production process that makes optimal use of the predicted next industrial revolution. The influence of Computer-Aided Design (CAD), which has rapidly grown throughout the past decades, is currently complemented by a growing influence of Computer-Aided Manufacturing (CAM).

Digital fabrication creates a direct link between our digital and physical worlds and has the potential to increase the performance of construction processes [9].

Figure 15: Installing parts such as Lego pieces, where a special adhesive is used for fifteen years.
Source: [23].

Building a Designer can also be understood by non-experienced designers and can run on simple platforms like mobile phones. A CNC milling machine that laser-cuts the required 2484 parts out of fiberboard for a house that can be assembled, without any external material as the parts are simply slid together thanks to friction fit, a technique somewhat similar to Lego blocks or click furniture. Each separate component has been designed with special joinery, allowing it to perfectly fit its neighboring piece. The framework, flooring, roof, and walls are all made from individual, interlocking sections that link together like puzzle pieces [10].

Figure 16: Made entirely from digitally fabricated components, a CNC milling machine laser-cuts the necessary pieces out of fiberboard, which can be assembled without the need for any additional materials like screws and fixtures.
Source: [10].

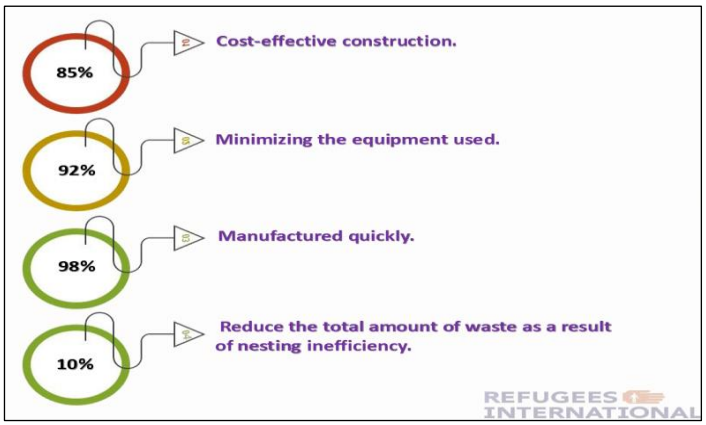

Figure 17: Post-use occupancy, Haiti's shelter.
Source: Author, (2020).

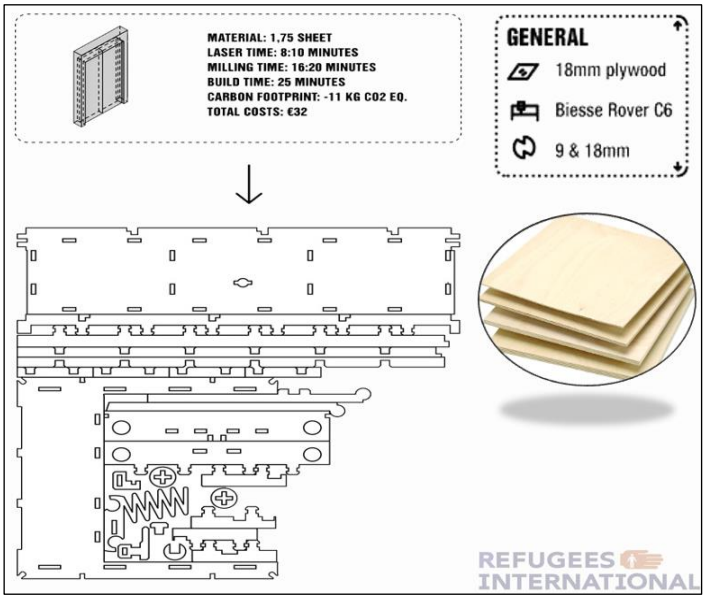

Figure 18: Materials used, each CNC-milled panel, made of reused-wood &waterproofed with Nano-coating chemicals, would be jointed in three directions, thereby creating a strong bond without the use of metal fittings, screws or glue.
Source: [15].

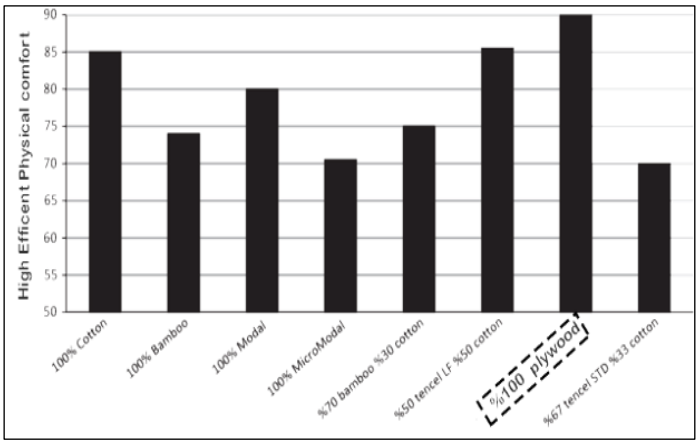

Figure 19: Post-use occupancy, Materials Haiti's shelter.
Source: Author, (2020).

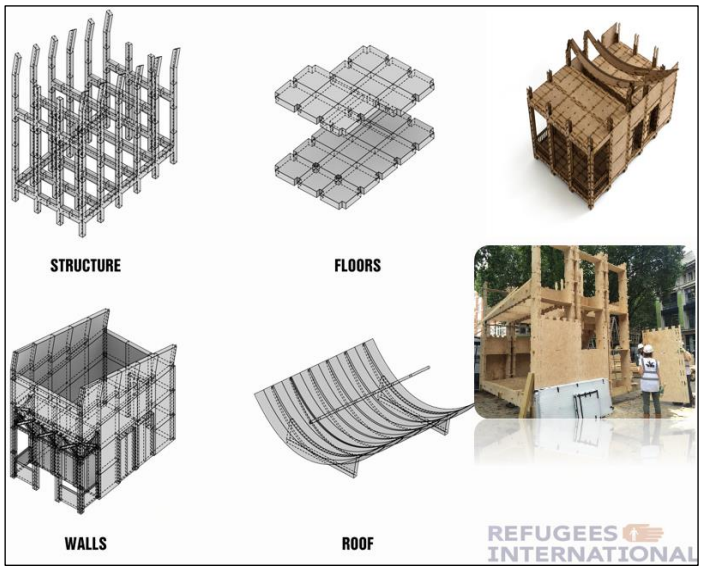

Figure 20: Structure Element and phase, Haiti's shelter.
Source: [9].

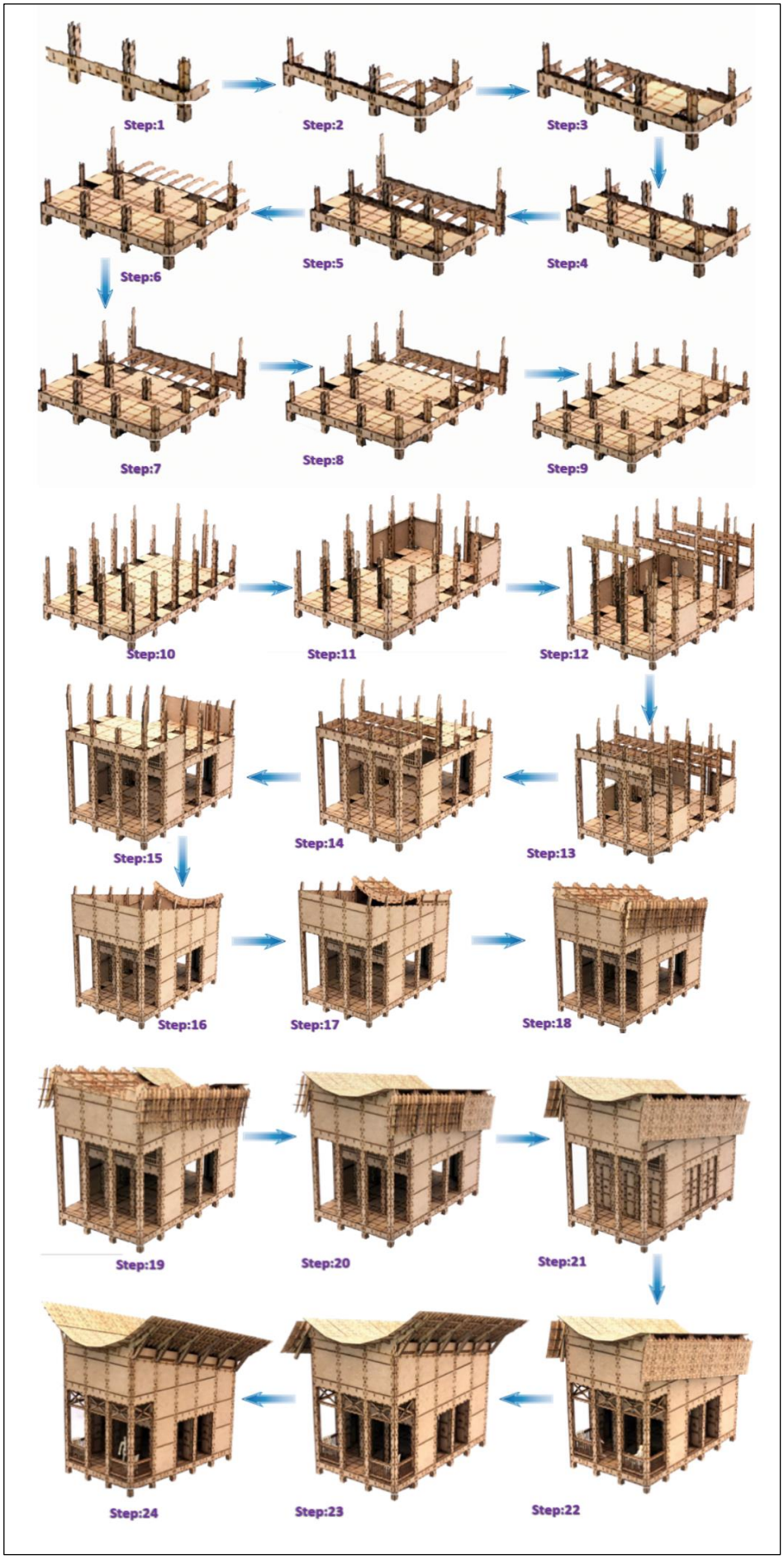

Figure 21: Structure Element and Construction Phase, Haiti's shelter.
Source: Author, (2020).

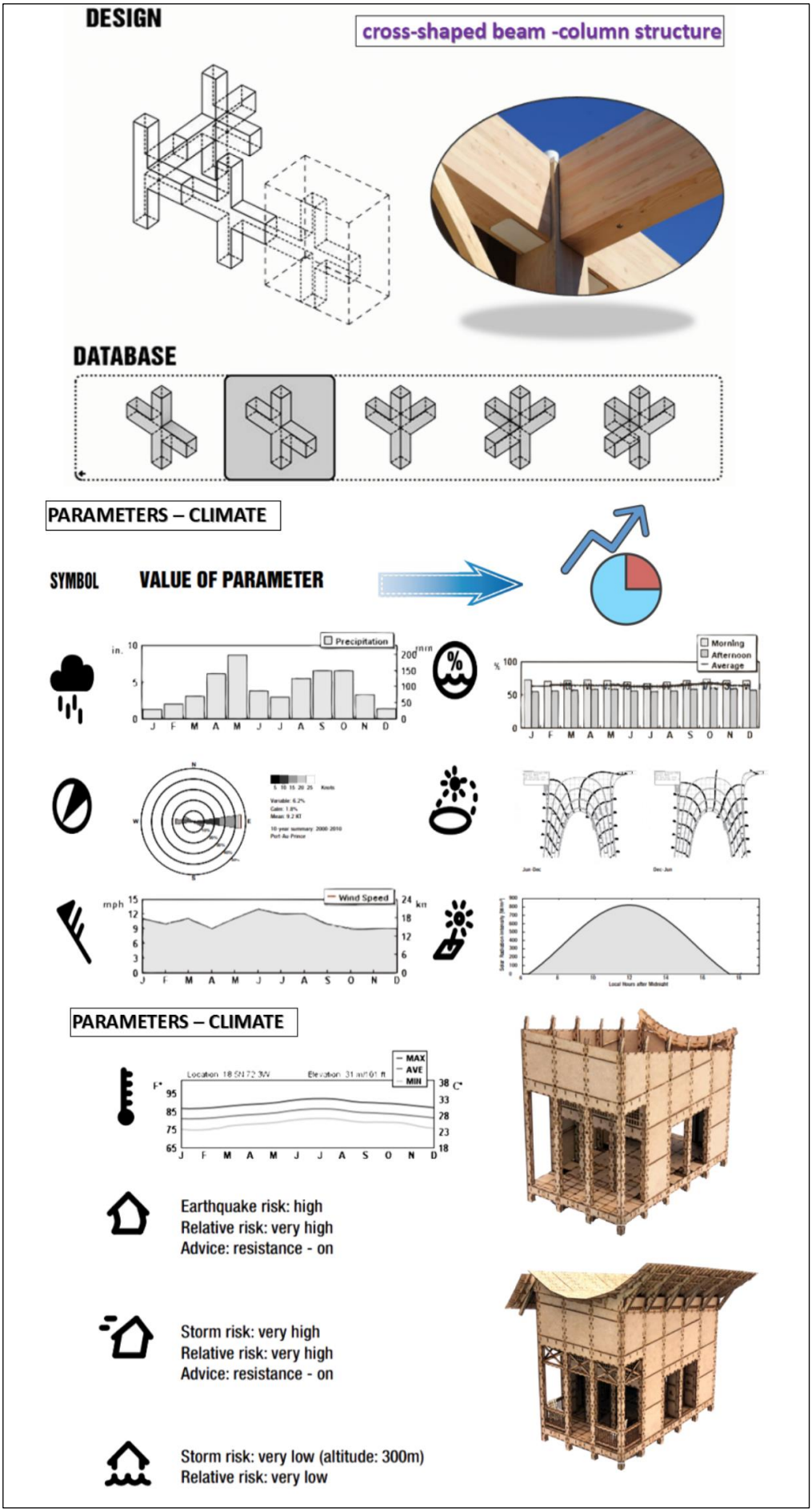

Figure 22: Climate Consideration, Haiti's shelter.
Source: [25].

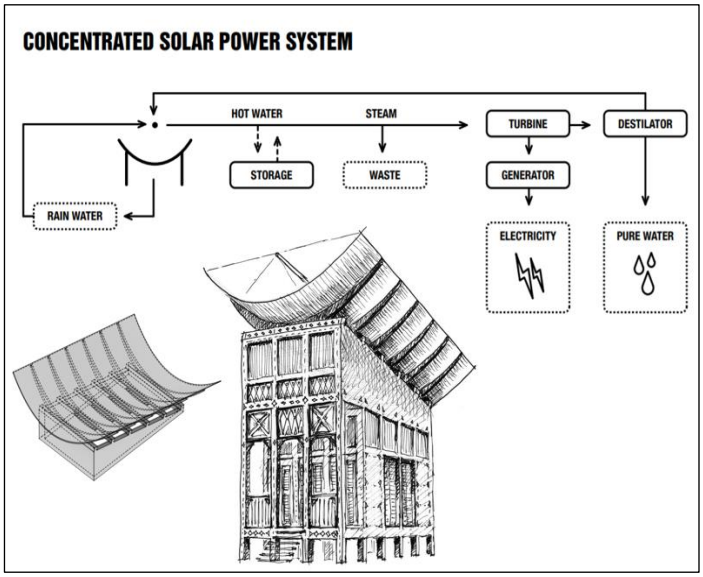

Figure 23: SUSTAINABLE FEATURES, The roof plays a key role in providing the three most basic needs of homeless people.
Source: [25].

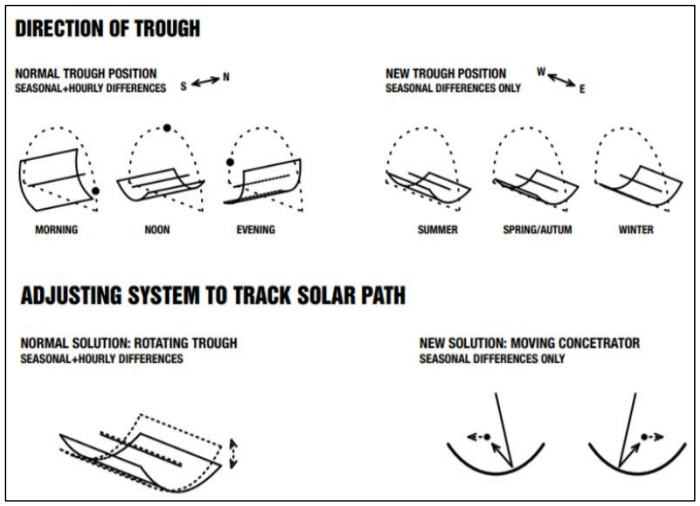

Figure 24: The roof design is following the principles of sustainability in architecture.
Source: [12].

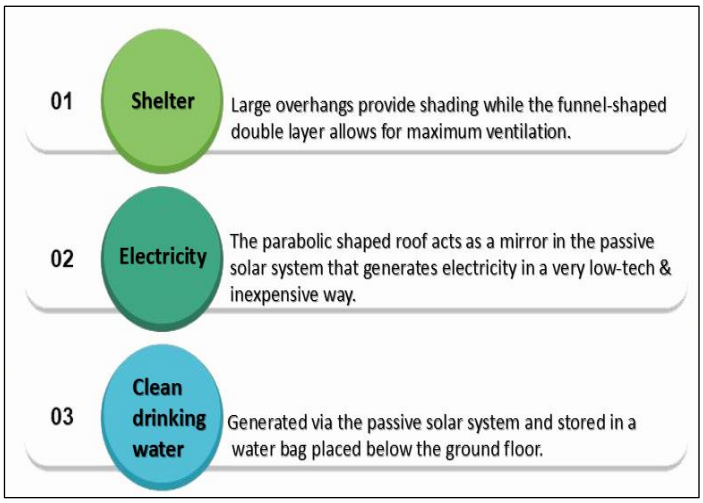

Figure 25: Sustainable Features, The roof plays a key role in providing the three most basic needs of homeless people, Haiti's shelter.
Source: [20].

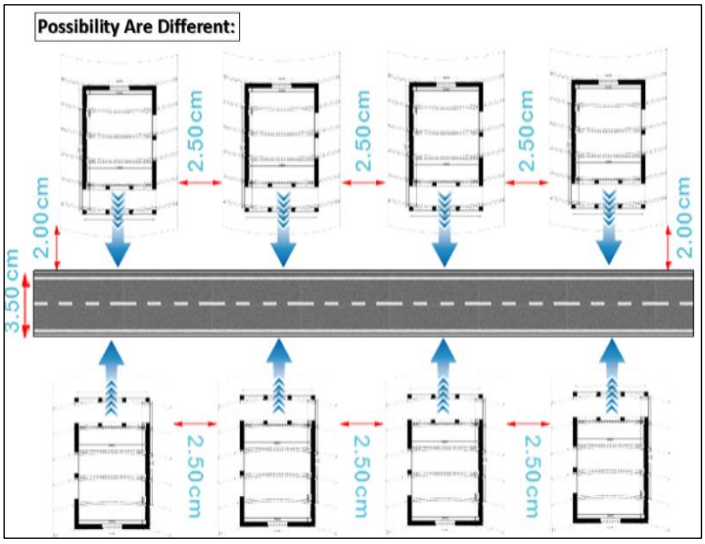

Figure 26: Way puts unite; the units are placed next to each other so that the short side that contains the balcony is directed directly to the street, Haiti's shelter. Haiti's shelter.
Source: Author, (2020).

Summarizing the strengths of designing Haiti's shelter, wall thickness can be adjusted to meet insulation requirements, the building designer relied on assembling the components in a compact size to make the building lose its heatless, determining the quantitative and qualitative performance metabolites in a balanced and effective manner without restricting site freedom, ease of adaptation and expansion of the building system while reducing its complexity, and the new building system is a mix between the balloon system and the column & beam system, this combination increases the efficiency of materials while allowing the physical [26].

III. CONCLUSION

It can be concluded that most sites in developing countries are characterized by disasters and crises that destroy housing systems. A quick, constructive solution must be found to house the displaced groups and achieve the minimum level of rest, encouraging construction in recyclable and reusable natural materials such as bamboo, straw bale, rammed earth, and adobe in economic & environmental crises, supporting the idea of self-construction and local employment without using large amounts of resources and importers, leading to the integration of more solutions, and it is important to take into account climatic conditions in crisis areas to understand how the local workforce manages the project and to create sustainable environmental remedies in the shelter and settlement to provide the minimum level of physical and psychological comfort for internally displaced groups.

IV. AUTHOR'S CONTRIBUTION

Conceptualization: Zaid Mohammed Al-Zrigat.
Methodology: Zaid Mohammed Al-Zrigat.
Investigation: Zaid Mohammed Al-Zrigat.
Discussion of results: Zaid Mohammed Al-Zrigat.
Writing – Original Draft: Zaid Mohammed Al-Zrigat.
Writing – Review and Editing: Zaid Mohammed Al-Zrigat.
Resources: Zaid Mohammed Al-Zrigat.
Supervision: Zaid Mohammed Al-Zrigat.
Approval of the final text: Zaid Mohammed Al-Zrigat.

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RESEARCH ARTICLE OPEN ACCESS

THE IMPACT OF MOTOR STARTING ON THE QUALITY OF THE INDUSTRIAL ELECTRICITY NETWORK

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Startup Time,
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ABSTRACT

The use of electric motors in the industrial sector has become increasingly important, especially with the development of power electronics. However, the use of these motors poses many problems, including the starting problem. Our work focuses on the study of the impact of the starting of electric motors on the quality of the industrial electricity grid, such as voltage drops during and after the starting, increasing the starting current to exorbitant values, and the starting time becoming too long. Besides, we propose solutions for these problems, such as compensation of the reactive power, insertion of VFD, and lag in the starting time of the motors. In the end, do a comparative study between these different solutions to justify the choice that is the insertion of VFD.

I. INTRODUCTION

Electric motors, due to their robustness and their weight/power ratio, are widely used in industry [1]. Ensuring their continuity of operation requires the implementation of starting systems.

The most important phenomenon is the starting process of electric motors throughout the operation of these motors. Usually, an electric motor started by power-up. However, three possibilities should be considered:

- Interference with the power supply in the form of an excessive voltage drop, which is greater than that which can be tolerated by other equipment or other consumers.
- Starting currents will add to the heating of the motor in an amount that depends on their RMS values and the starting frequency. The currents excessive can damage the motor itself, as well as the connecting cables [2].
- Starting time, which can affect the stability not only of the electric motor but the entire power system [3].

The present paper focuses on analyzing the impact of starting electric motors on the industrial electrical network. Show the different problems caused by the starting electric motors and finding solutions to these problems.

In this paper, we have proposed three solutions. The first solution is to insert batteries capacitors to compensate for reactive power and subsequently improve voltage during starting motors. The second solution is the insertion of the variable frequency drive (VFDs) to motor start gradually. The third solution is shifting the start time of the electric motors in the different production workshops. We have used a practical and powerful simulation tool that is ETAP 12.6.

The remainder of this paper organized as follows: Section II represents different motor starting modes. Section III describes the presentation of the system adopted in this paper. In Section IV the results and discussion are evaluated, and Section V presents the conclusion.

II. THE DIFFERENT MOTOR STARTING MODES

When switching on an electric motor, the current draw on the network has become high, and the section of the supply cable has become insufficient, cause a voltage drop that may affect the

operation of the receivers. Sometimes this voltage drop is noticeable on lighting devices. To remedy these drawbacks, we require the use of different starting modes to reduce the current electricity. This section is devoted to the explanation of these starting modes.

II.1 THE STARTING PROBLEMS OF AN ELECTRIC MOTORS

When starting an AC motor, the three-phase asynchronous motor works like a transformer, in which the primary (stator) is under voltage, and the secondary (rotor) is short-circuited the current drawn is then very high [4]. Depending on the type and the power of the motor, the starting current can reach 4 to 10 times the rated full load current. This significant current draw of short duration that the motor could withstand it without risk of dangerous heating. Moreover, it is a hindrance to the distribution of electrical energy and the users in the vicinity on the same line, causing falls excessive voltage, which is then necessary to reduce this starting current [5].

II.2 THE STARTING CHOICE

The choice of starting conditioned by economic and technical criteria that are:

- The Mechanical characteristics.
- The desired performances.
- The nature of the electricity supply network.
- The use of the existing motor in the case of retrofitting.
- The company's maintenance policy.
- The cost of the equipment.

II.3 THE MAIN STARTING MODES

There are various starting modes and the most important starting methods used in the industry are shown below [6]:

Classic start

- Direct start
- Star-delta starting
- Starting by stator resistors
- Starting by rotor resistors
- Start by autotransformer

Soft start (electronic) [7]

- Start by an electronic converter
- Starting by frequency converter

III. SYSTEM PRESENTATION

The system proposed for this study is presented in Figure 1. Which is a small industrial production unit, consists of the following:

- A 30 kV medium voltage distribution network power source.
- Two 30 kV transformers (T1, T2) delivering to the factory 0.38 kV busbar (Bus12, Bus14). With 800KVA of power for each one, connected to the 0.38Kv busbar by two cables (cable11, cable12), with a length of 60 and 90m, respectively.
- Four production workshops:
- Workshop1: This workshop is supplied by the main switchboard by cable 12. Consists of three production machines delivered with 0.38 kV (Mtr1, Mtr2, Mtr3) of power 60kW each one, connected to the 0.38 kV busbar, each motor connected to the busbar via a cable of a specified length. Plus, a load that represents lighting of 30KVA of power.
- Workshop2: This workshop identical to workshop 1, is powered by the main switchboard by cable 11. Consists of three production machines supplied with 0.38 kV (Mtr4, Mtr5, Mtr6) with a power of 70KW each one, connected to the 0.38 kV busbar, each motor is connected to the busbar via a cable of a specified length. Plus, a load that represents lighting of 30KVA of power.
- Workshop 3: This workshop is supplied from workshop 1, 0.38 kV, by cable 9. It is composed of three production machines of 70kW and lighting load of 30KVA.
- Workshop4: This workshop is identical to workshop 1, except that it is supplied from workshop 2, by cable 13.

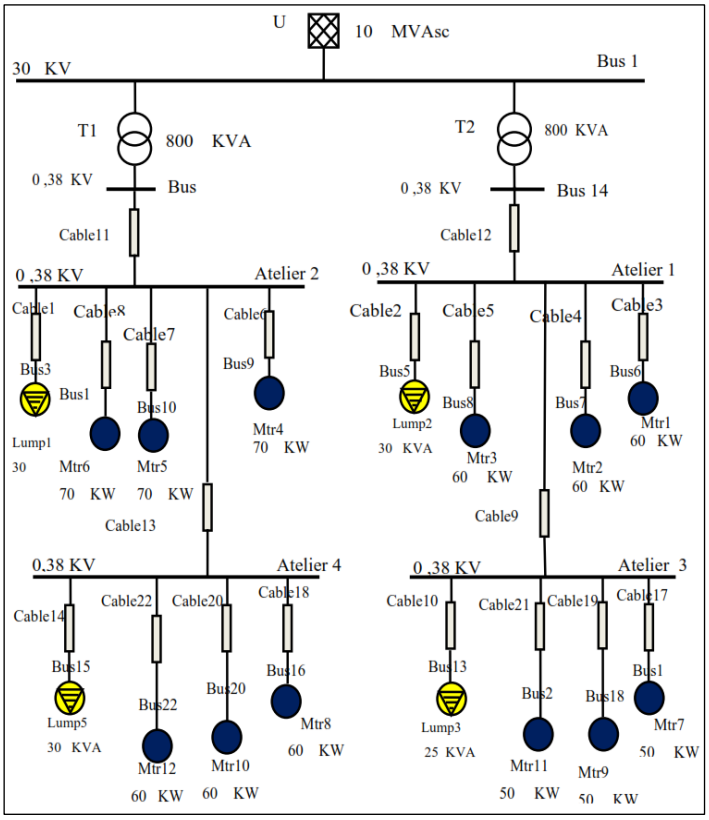

Figure 1: Structure of the proposed industrial electricity network.
Source: Authors, (2020).

IV. RESULTS AND DISCUSSIONS

In this section, simulation studies were carried out. To verify and analyze the impact of starting electric motors on the industrial electricity network, we used practical and efficient software "ETAP 12.6.", by which we ran several simulations to see the problems caused by starting electric motors and their solutions.

IV.1 POWER FLOW

Before starting the dynamic electric motor starting simulations, we found it necessary to perform the power flow simulation to check the voltage levels and see the state of this network. For this purpose, we have inserted the system represented previously in the ETAP software, which is shown in Figure 2. After running the power flow simulation, we got the results shown in the same figure.

From the power flow simulation results, we can see that the voltages are within an acceptable range according to international standard because all the voltages levels from the different workshops are above 90% and below 110%.

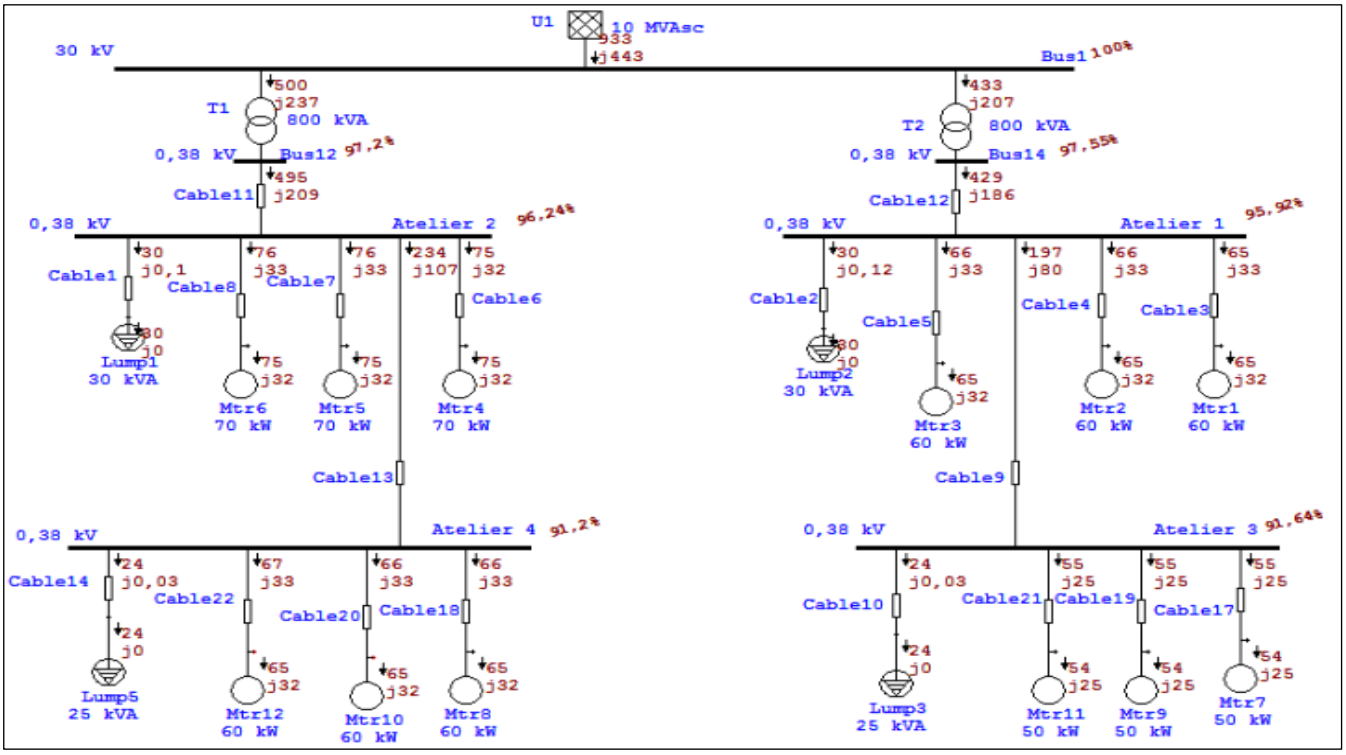

Figure 2: Power flow results.
Source: Authors, (2020).

IV.2 MOTOR START SIMULATION

After checking the condition of our network, we will run the dynamic simulation of the electric starting motor to see the impact of the starting on the industrial power grid.

In this phase, we proceeded to adjust our system, already integrated into the ETAP software, acting on the parameters, the total duration of the simulation, the starting time of each motor. After we performed the starting programming, we launched the simulation. We got the results shown in the following figures.

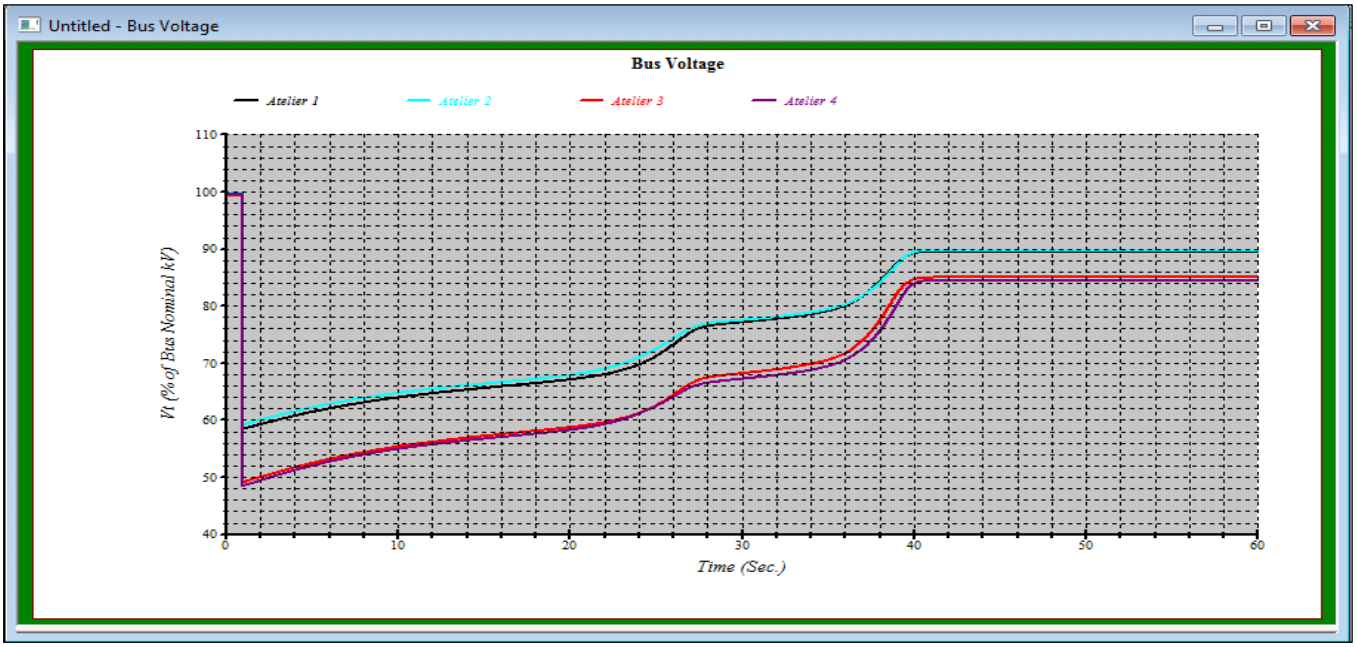

Figure 3: The voltage of the motors during the starting of the motors as a function of time.
Source: Authors, (2020).

According to these results presented in figure 3, we notice that the level of voltages during the starting is less than 60% for the two workshops 1 and 2, and less than 50% for the two workshops 3 and 4. Followed by the increase voltage gradually until the end of the starting period, the voltage reaches a level lower than 90% after a time of 40s from the starting time of the electric motors.

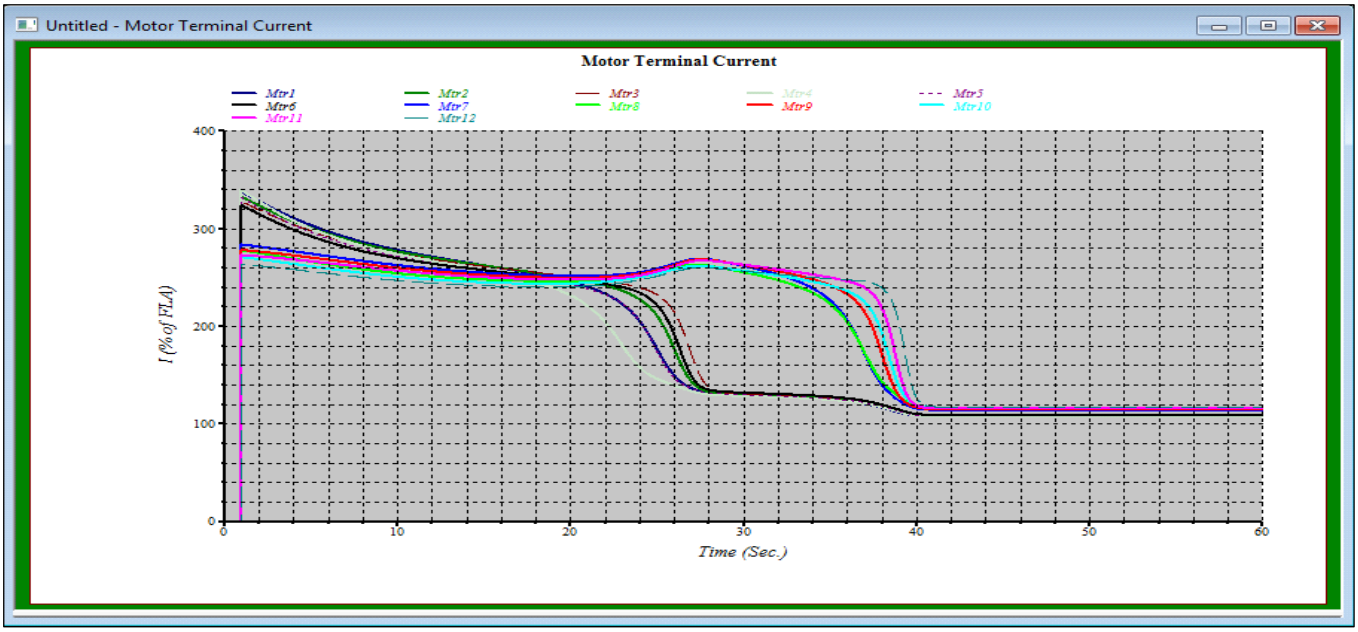

Figure 4: The starting current of the motors as a function of time.
Source: Authors, (2020).

From this simulation result, it can be seen that the starting current is approximately 300%, i.e. the starting current $I_d = 3.I_n$, and decreases to the rated current after 40 seconds.

IV.3 MOTOR STARTING PROBLEMS

From these simulation results, we can see that the starting electric motors cause the following problems:

- The starting current of the motors Id reached (Id = 3In) for a period of 40 seconds. This increase can cause the motors and the power cables to overheat, leading to the deterioration of the latter.
- The starting voltage level is reduced below 90% (less than 90%): by causing excessive voltage drops which have an influence on the industrial electrical network, this voltage drop can lead to a blackout.
- The transient period which is the period of starting motors is too long, during this period the power supply system is unstable, which can cause instability of the whole system.

IV.4 THE PROPOSED SOLUTIONS

In order to resolve the problems mentioned in the previous section, related to starting electric motors, the following solutions are proposed:

1. Insertion of capacitor banks for reactive power compensation since it concerns a voltage drop problem.
2. Insertion of frequency converters to start the machines gradually, VFD (Variation Frequency Driver).
3. The shift of motor starting time.

IV.4.1 Insertion of the Compensation Capacitor Banks

To solve the problem of the voltage drop, we have found it useful to use reactive power compensation by inserting capacitor banks. We have inserted these batteries at the level of the four production workshops, as shown in Figure 5.

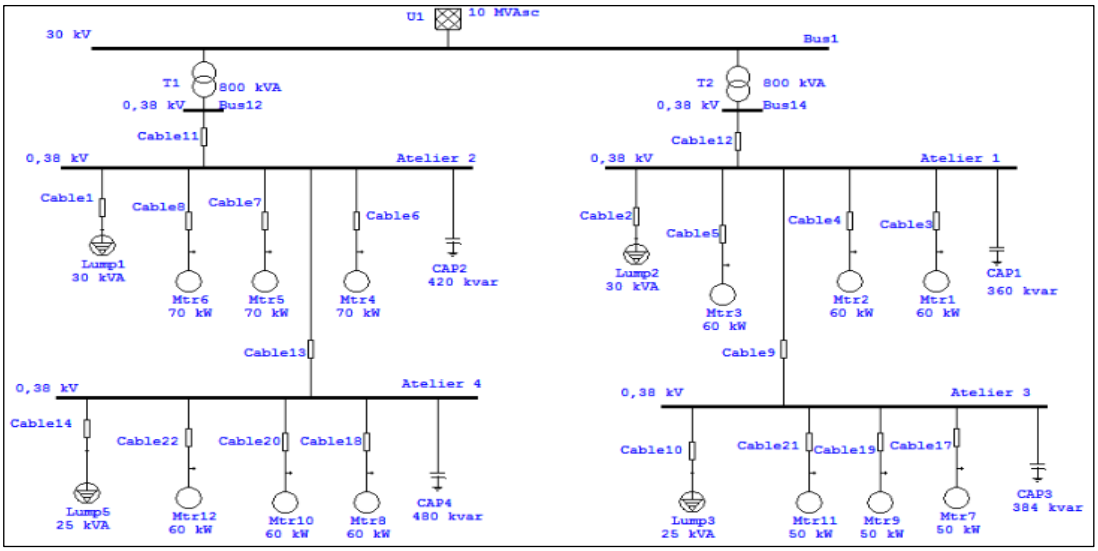

Figure 5: The Insertion of capacitor banks in the workshops.
Source: Authors, (2020).

Before starting the simulation of this part we adjusted the number of capacitor banks to find good results and improve the voltage level during the starting period. After this tuning step we started the power flow simulation, the results are shown in Figure 6.

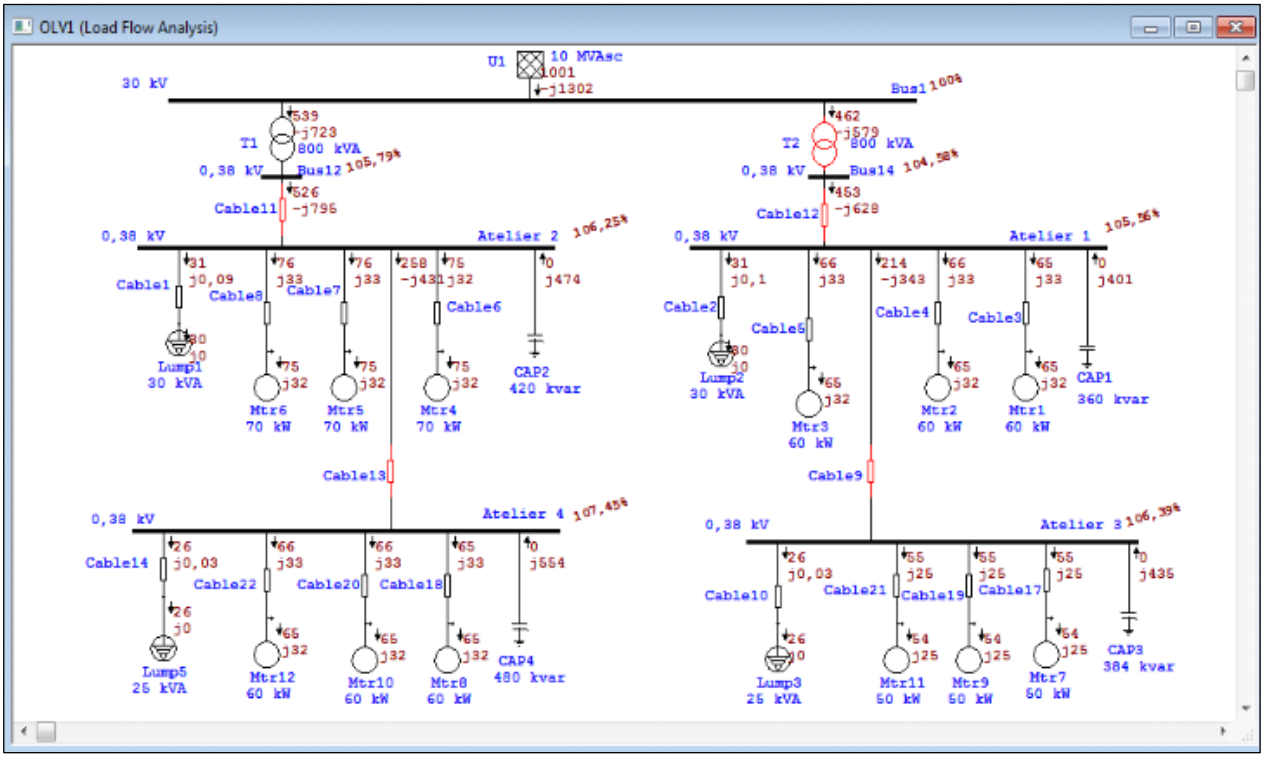

Figure 6: The result of the power flow after inserting the batteries.
Source: Authors, (2020).

From these results, it can be seen that the voltage levels are acceptable, as the voltage levels are> 90% and <110%.

After checking the voltage levels of the different workshops, we launched the dynamic simulation of the starting of the electric motors of the different machines in the different workshops, we obtained the results presented in Figure 7.

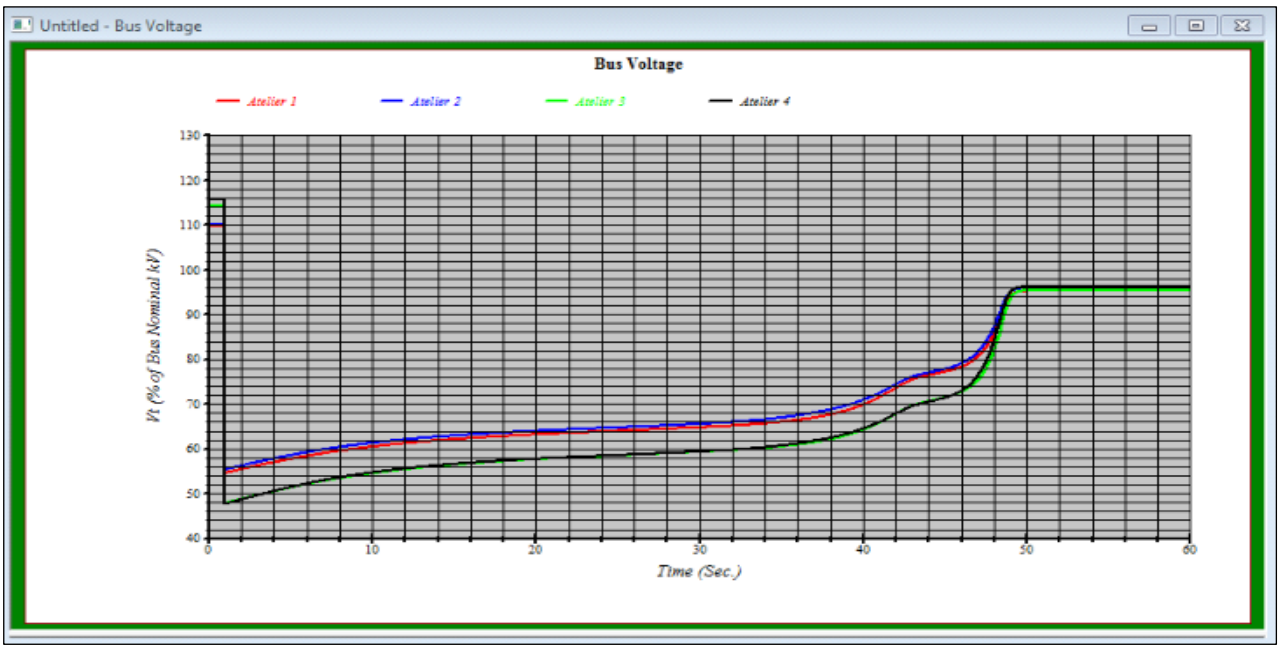

Figure 7: The starting voltage of the motors as a function of time after the insertion of the capacitor banks.
Source: Authors, (2020).

The diagram clearly illustrates that the use of compensation by capacitor banks improves the voltage during the period dynamic, i.e. after the starting period. However, during the starting time, the voltage level remains below 90%. As also seen in Figure 8, the starting current during the starting of the machines equals three times the rated current, i.e. no improvement.

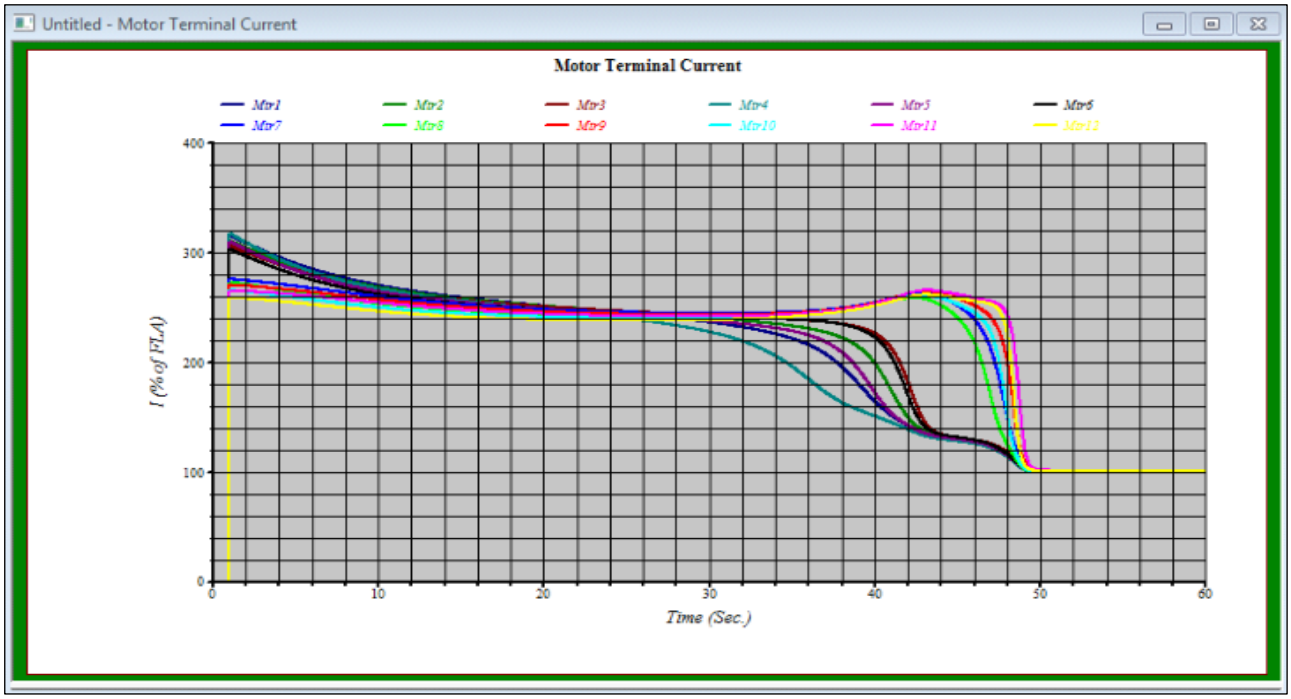

Figure 8: The starting current of the motors as a function of time after the insertion of the capacitor banks.
Source: Authors, (2020).

IV.4.2 Insertion of the Variable Frequency Drive (VFD)

The VFD is an electrical device used to adjust the speed of an electric motor used in industrial electricity. The use of VFDs will allow the acceleration of the controlled motor during the starting time by controlling the frequency [8], [9]. For this purpose, we have inserted these VFDs in series with the power supply of the motors incorporated in the production machines of the different workshops, as shown in Figure 9.

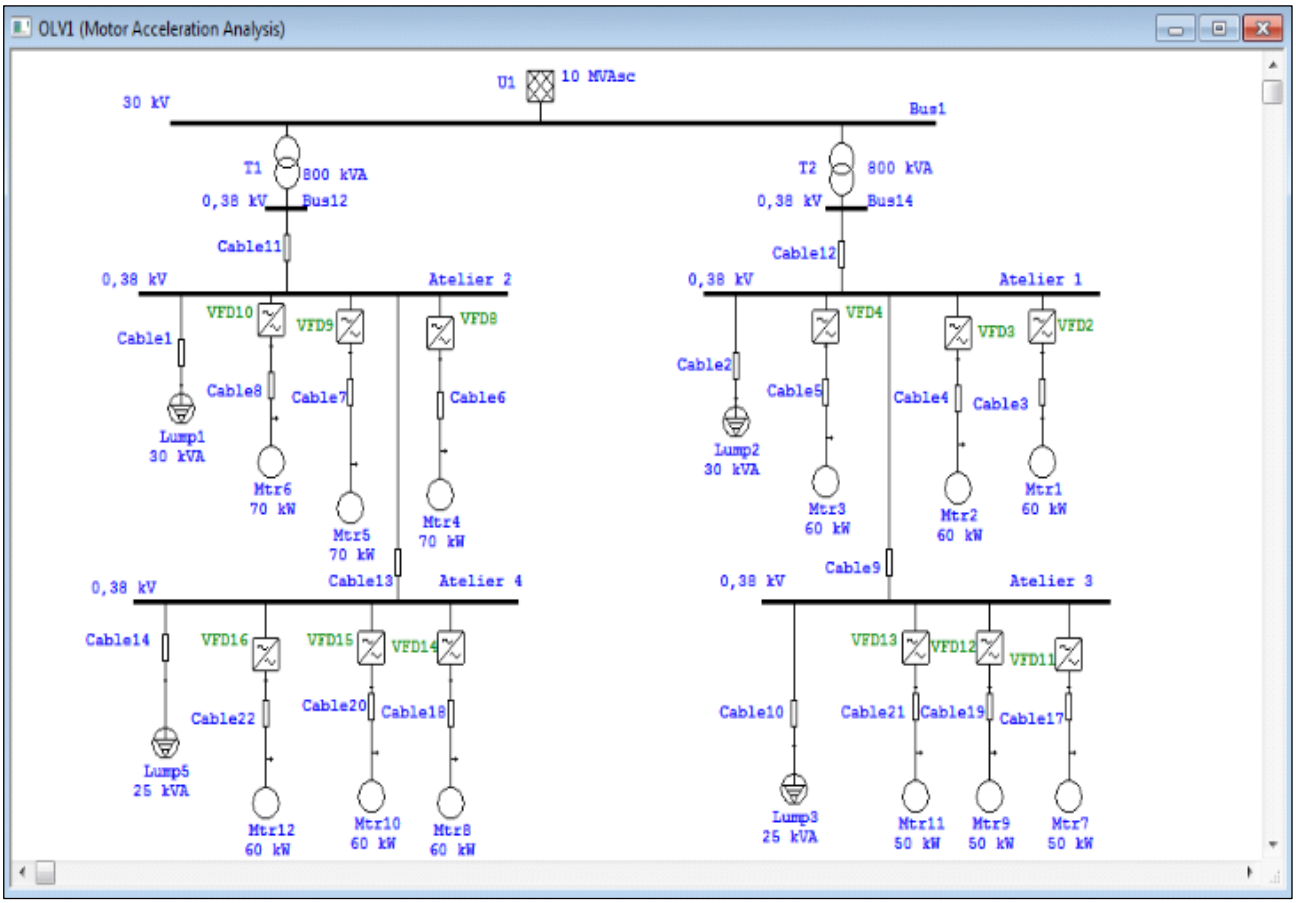

Figure 9: The insertion of VFDs into the industrial electricity network.
Source: Authors, (2020).

We proceeded to adjust these VFDs, starting with the power and supply voltage adjustment shown in Figure 10, followed by setting the start frequencies, as shown in Figure 11.

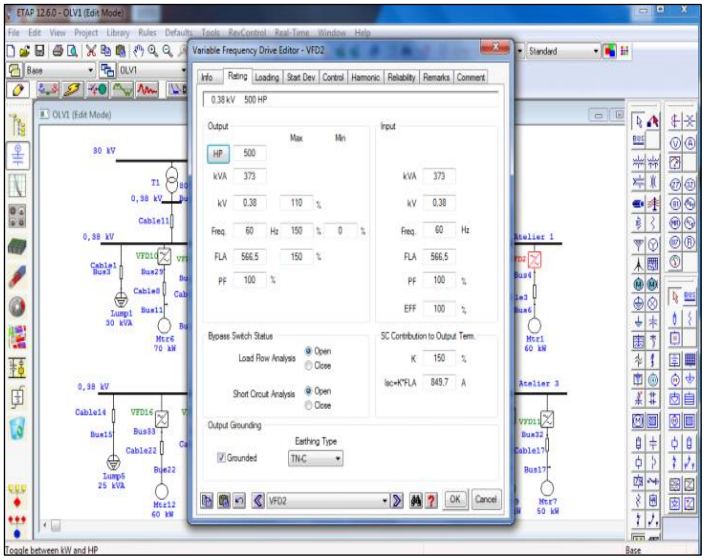

Figure 10: VFD power supply adjustment.
Source: Authors, (2020).

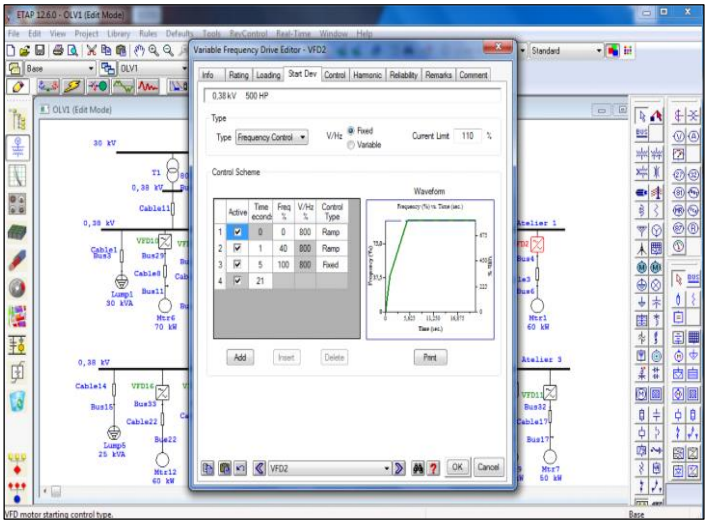

Figure 11: Setting the starting frequencies VFDs.
Source: Authors, (2020).

After this adjustment, we have checked the voltage levels by the power flow simulation, it can be seen in Figure 12 that the voltage level is <100% and> 90%, i.e. that the voltage level is acceptable.

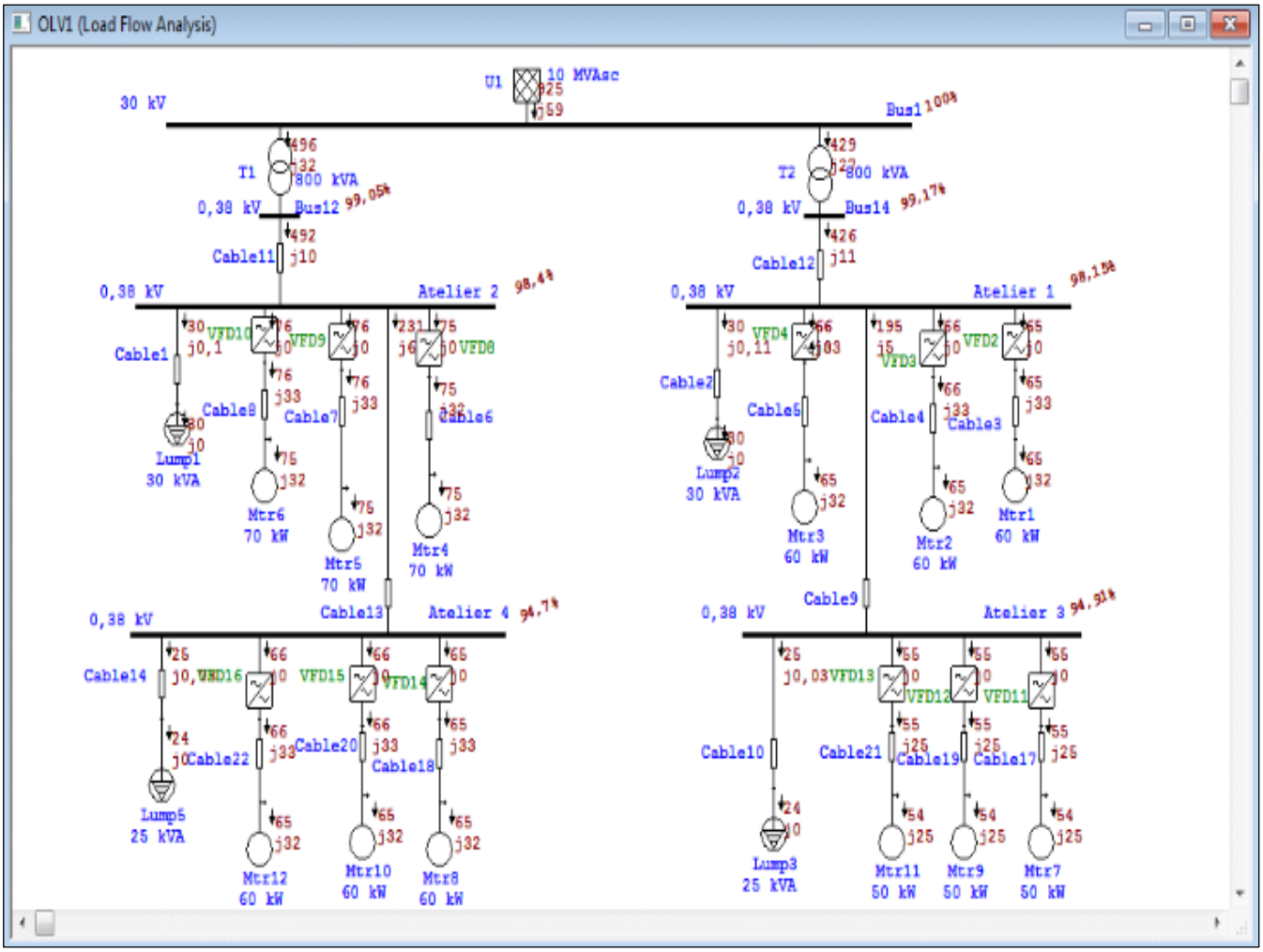

Figure 12: The power flow after insertion of VFDs.
Source: Authors, (2020).

After checking the voltage levels, we launched the dynamic simulation of the starting motor with the insertion of VFDs. The results are shown, in the following figures.

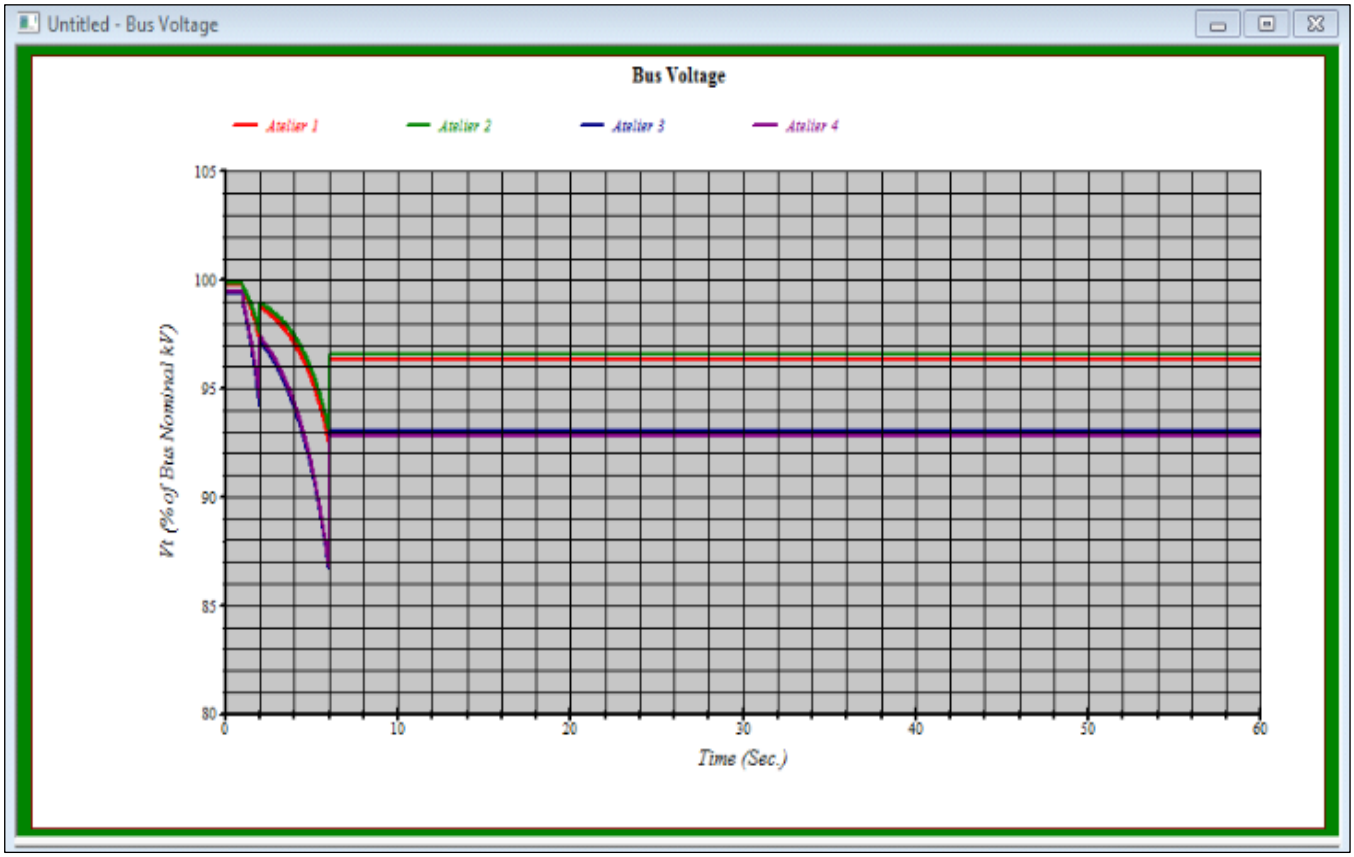

Figure 13: The voltage level after insertion of the VFDs.
Source: Authors, (2020).

Figure 14: The starting current after insertion of the VFDs.
Source: Authors, (2020).

From the results of Figure 13, it can be seen that the voltage during starting increased to 87%, and after starting i.e. during regime dynamic, the voltage level has a fixed value that is 93%. We also notice that the time starting is reduced to 8 seconds.

Also, can be seen, in Figure 14, the starting current is reduced by up to 120%, i.e. 1.2 of the rated current.

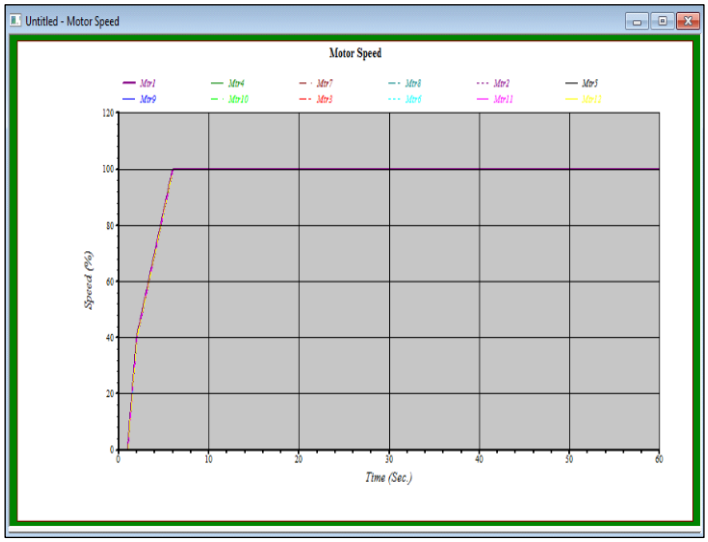

Figure 15: The starting speed after insertion of VFDs.
Source: Authors, (2020).

Figure 15 clearly illustrates that the starting speed followed the frequency adjustment made in the VFD tuning box, so the motors took 8 seconds to start and reach dynamic speed.

IV.4.3 Motors Starting Time Lag

In this phase, we tried to simulate the third part which is the shifting of the motors start time in the different workshops. For this purpose, we have adopted the following setting, as shown in figure 16. We programmed the start of the first motors of each workshop at the first second, then we programmed the start of the second motors of each workshop at the 10th second, finally, the third motors of each workshop at the 20th second.

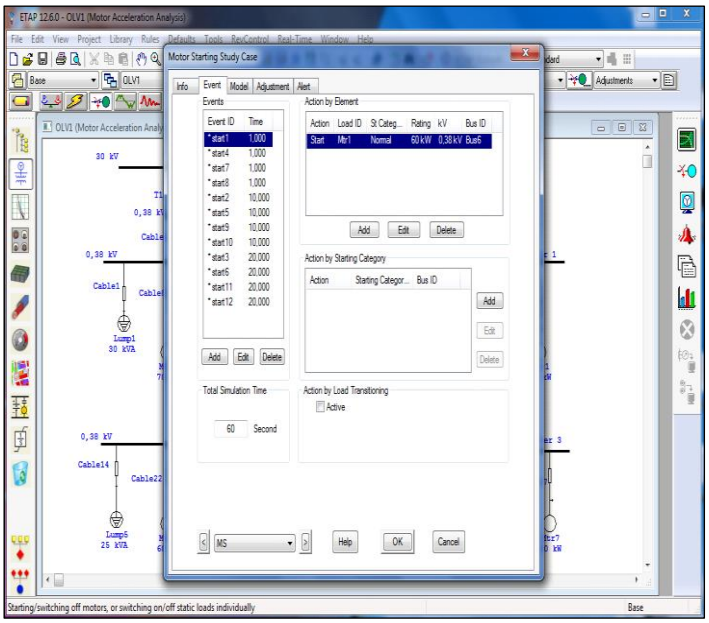

Figure 16: Adjusting the motors starting time.
Source: Authors, (2020).

After setting the starting time setting, the dynamic simulation of the starting of the motors was launched, the results obtained are shown in the following figures.

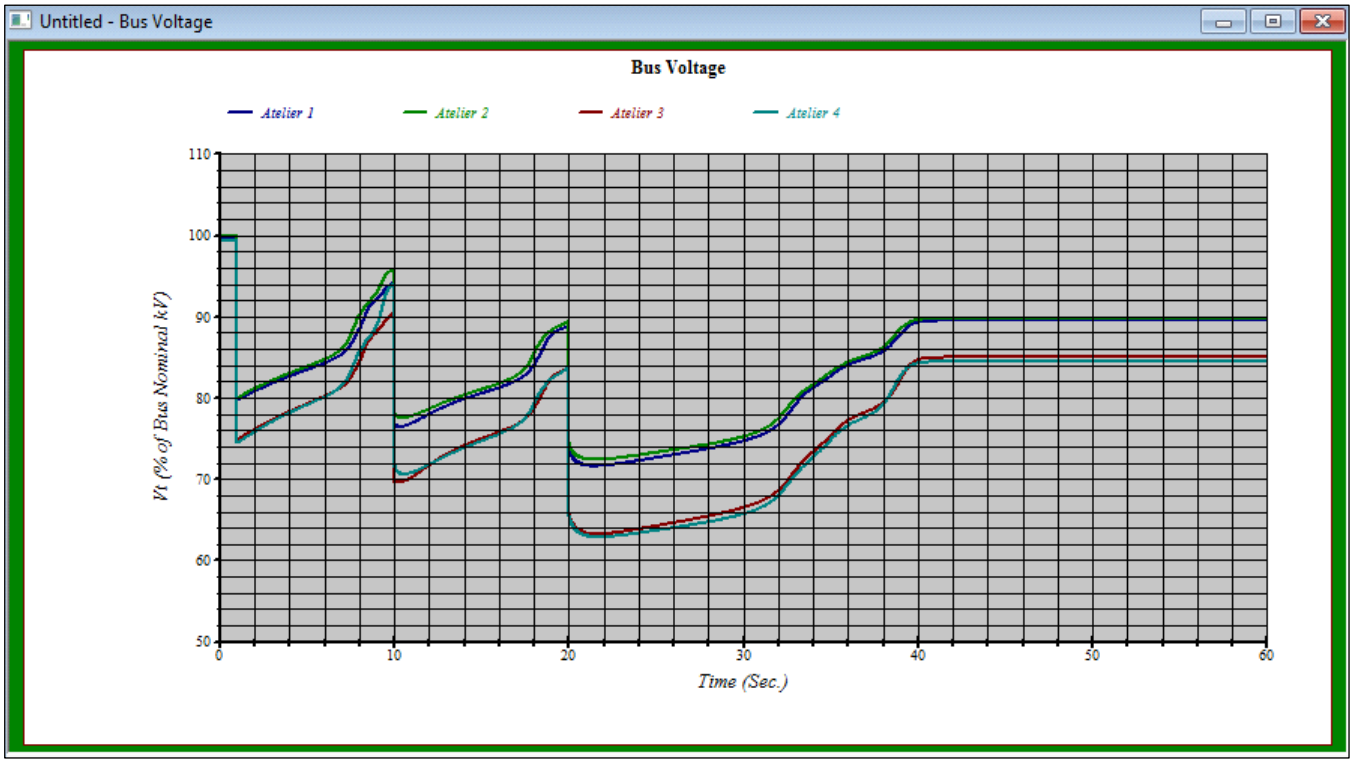

Figure 17: The Voltage level after start time delay.
Source: Authors, (2020).

Figure 17 shows the level of the voltages of the different workshops. We notice that the voltage increased to 61%, the starting period reduced between 10 and 20 seconds.

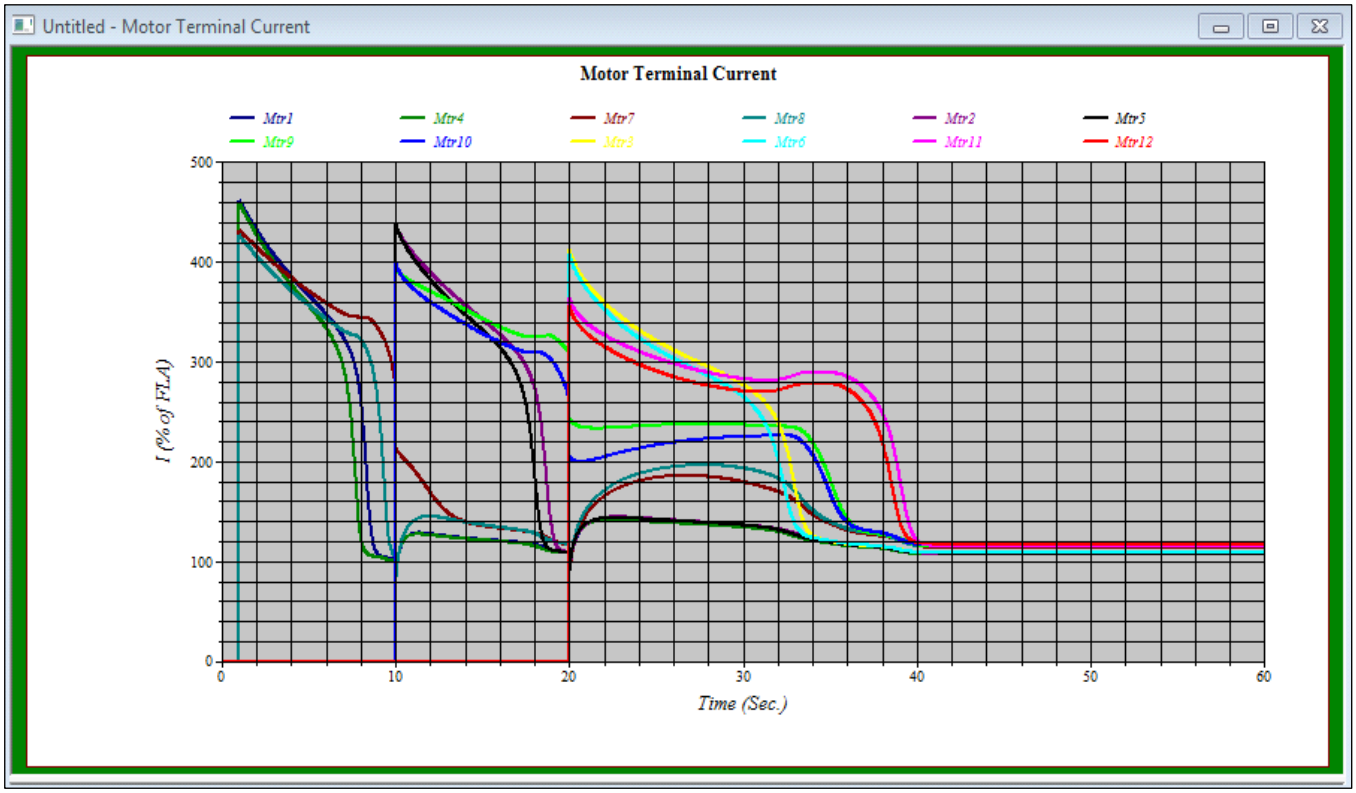

Figure 18: The starting current after the shift of start time.
Source: Authors, (2020).

Furthermore, in Figure 18, we notice that the starting current increased up to four times the rated current.

IV.5 RESULTS INTERPRETATION

It can be seen, from the obtained results, that the insertion of VFDs gives good results. The level of voltages during starting is acceptable as it is higher than 85%, after starting i.e. during steady-state the voltage level reaches a value of 97%, which is a sufficient value. The starting current reaches up to a value of 1.05 of the rated current, which is a very acceptable value. We also note that the insertion of VFDs reduces the starting time (transitional period) up to 6 seconds.

Two criteria must be verified to select and adopt a solution among the proposed solutions, which are technical and economic criteria. Technically, the insertion of the VFDs is better compared to the other solutions, but economically the choice of the start time-shifting is very suitable.

V. CONCLUSIONS

In this study, we started by presenting our system, which is composed of a 30kV power source, two 30kV/380V step-down transformers, four production workshops with their connection to the mainboard, and the various loads (machines, lighting … .Etc.) constituting each workshop.

We have created this overall system in the ETAP software by setting the parameters of each component. We started with the first simulation of the power flow verification. Also, the dynamic simulation of the motors starting launched in 60 seconds. The results obtained show that the system during the starting suffers from the following problems:

- Voltage drop during the starting time and also during the period dynamic.
- Increase in starting current up to 3 to 4 times the nominal current.
- The starting time is too long.

To solve these problems, we have proposed three solutions.

The first consists of inserting capacitor banks for reactive power compensation and subsequently improving the voltage. The second solution, inserting frequency converters to start the motors gradually. Finally, the third solution, the delay in electric motors starting.

The results obtained show that the second solution, which is the insertion of VFDs. is efficient because this solution not only improved the voltage and decreased the starting current, but it also reduced the starting period. The next step of this work is to try the insertion of the static converter.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: H. Guentri, B. Boutaleb and B. Benazzedine.
Methodology: H. Guentri and B. Boutaleb.
Investigation: H. Guentri and B. Benazzedine.
Discussion of results:H. Guentri, B. Boutaleb and B. Benazzedine.
Writing – Original Draft H. Guentri and K. Ezzaeri.
Writing – Review and Editing: H. Guentri and K. Ezzaeri.
Resources: B. Boutaleb.
Supervision: B. Boutaleb and B. Benazzedine.
Approval of the final text: H. Guentri, B. Boutaleb and B. Benazzedine and K. Ezzaeri.

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RESEARCH ARTICLE OPEN ACCESS

BASE ISOLATION OF MULTI-STORIED BUILDING USING LEAD RUBBER BEARING

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Isolator,
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El Centro Ground Motion.

ABSTRACT

Earthquake resistance building design is the most important thing to ensure safety and minimize loss in recent years. Nowadays, many techniques are being used in earthquake resistance building design. Base-isolation is one of the best techniques used in earthquake resistant design building in economical. It reduces seismic energy transmitted to buildings, in highly seismic prone areas. Lead Rubber Bearings are the most widely used technology in seismic base isolation, because of its technical and economic effectiveness and reliability. In this research, a multi-storied building that is located in Dhaka city is performed at numerically design as a base isolation building where the lead rubber bearing is designed and used as isolator. The building is analyzed for El Centro earthquake data of 15, 20, and 25 second. For base isolated and non-isolated condition nonlinear time history analysis is done using SAP2000 18. By comparing displacement vs time, acceleration vs time graphs for base isolated and non-isolated condition, the displacement difference between top and bottom floor is almost close that indicates this building structural behavior better during lateral load.

I. INTRODUCTION

Isolation means separation or closing-off. Base isolation also called as seismic base isolation or base isolation technique is one of the best method of protecting a structure against lateral forces such as earthquake loads. Base isolation define as structural elements that should separate a superstructure from its substructure resting on a ground motion or shaking thus protecting the structure. when structures are built according to code specifications (BNBC), they are expected to be damaged during strong earthquakes, but to remain upright. This conventional approach to seismic design is not acceptable for critical structures like hospitals, fire stations, and telecommunications centers.

Base isolation is an anti-seismic design strategy that can reduce the effect of earthquake ground motion by separating the superstructure from the foundation. The structure can be dissociated from the horizontal components of the ground motion by intervening structural elements with low horizontal stiffness between the foundation and superstructure [1].

II. LITERATURE REVIEW

At first base isolation was registered as a patent in 1800's, with Lead Rubber Bearing (LRB) providing high flexibility and damping. The natural rubber has been used for base isolation since 1840's, through the process of material development synthetic rubber or poly-tetra-fluoro-ethylene (PTFE) which is developed by DuPont was used, and designed for 50 years or more [2].

Investigated a smart base-isolation system using Magneto-Rheological (MR) elastomers, which are a new class of smart materials whose elastic modulus or stiffness can be adjusted depending on the magnitude of applied magnetic field. The results suggest the feasibility of using MR elastomers as variable stiffness elements for enhancing the performance of conventional base-isolation systems [3].

The total restoring force model of isolation device, a slide-limited friction base isolation technology. They analyzed the influential factors such as friction coefficient, elastic stiffness and yield displacement of displacement-constraint device on base isolation system [4].

In university of Asia pacific; over last some years there have been some studies in nonlinear analysis but they are not performed practical on base isolation system of the structure.

III. OBJECTIVE

The main objective of this study is to perform to analysis base isolated building and non-base isolated building under El Centro Earthquake data for (15;20;25 sec) and to compare the results with corresponding results from SAP2000 18 using nonlinear dynamic analysis. Some other objectives can be summarized as:

1. Study of Seismic demands of regular R.C buildings using the linear response spectrum and Non-linear time history analysis;
2. To illustrate the effects of base isolators, on the response of the High-rise Symmetric Buildings;
3. Perform numerical study (by SAP2000 18) of the ten-storied building models subjected to scale El Centro earthquake (15; 20; 25Sec) ground motion and compare the results of numerical studies with and without base isolation, changing of time duration of the earthquakes.

IV. METHODOLOGY

IV.I DESIGN OF LEAD RUBBER BEARING

Structural control system, base isolation system is classified as passive control. Isolators are the major devices that are implemented in a structural system for the purpose of isolation. The typical isolators are classified [5].

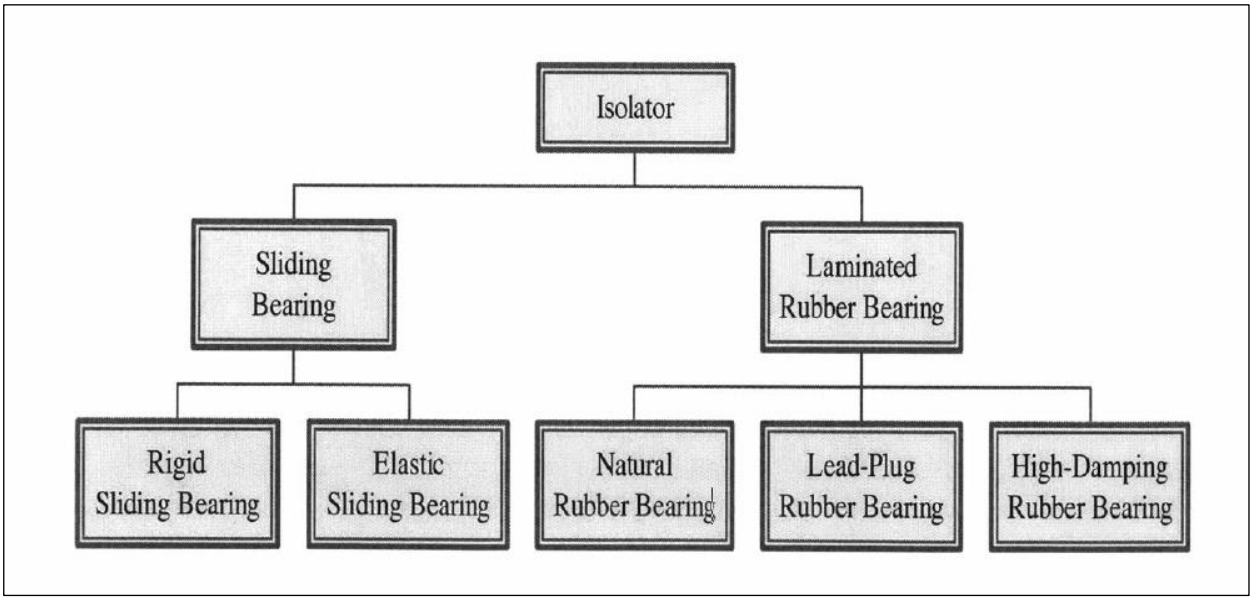


Figure 1: Types of isolator.
Source: Authors, (2020).

The dynamic quantities of the ten storied educational building located at Dhaka Total participated mass of the whole structure (M) = 16329325 Kg (approximately), Mass of base floor (M_b) = 1043262 Kg (approximately) Fundamental period of the building T_f = 0.15 (sec) Because M_b is relatively small in comparison with the mass of the superstructure, so this building is treated a single degree of freedom system in dynamic response system.

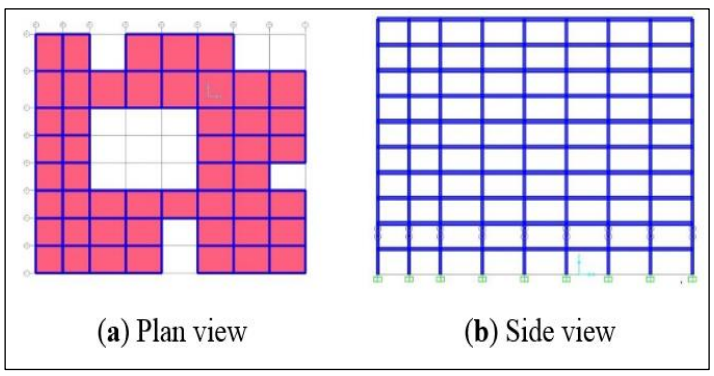


Figure 2: Plan and side view of isolated building.
Source: Authors, (2020).

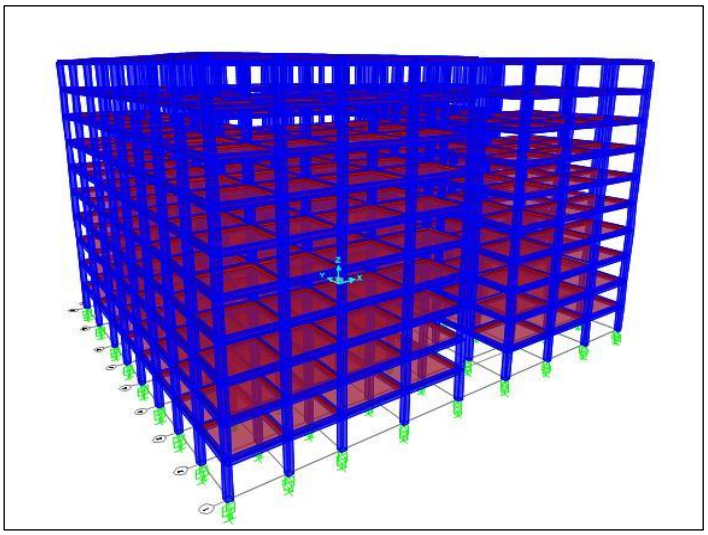


Figure 3: Base-Isolated Building Model.
Source: Authors, (2020).

Under isolation condition S_v = 0.6 (m/s). The system function are often associated with spectra velocity by$|U|_{max}$, finally, we will calculate for the displacement of isolators, U_b:

$$|U|_{max} = \frac{\Gamma S_v}{W_{eq}} = 2.19 \text{ x } 10\text{-}5\text{m} \quad (1)$$

$$U_b = \frac{K\,|U|_{max}}{K_b} = 0.087\text{m} \quad (2)$$

A typical design value of isolation layer is 0.3 (m) and therefore the value under the idea of Period T=0.3(sec) is on the brink of this target value which means that using this era can provide effective stiffness and optimal displacement for this building [6].

Lead-Rubber Isolators is usually more beneficial to start out designing isolation systems using lead rubber bearing isolators as a system then assign individual isolator properties. Therefore, we will use critical damping value 15% subject to verification and a rubber compound with a shear modulus of G=60 psi. The same target period of two.5 seconds maintaining or from [7]. For damping 15%; β_D= 1.35. Displacement at center of rigidity of isolation system at design basis earthquake (DBE); D or D_D [8];

$$D_D = \frac{(g/4\pi^2)S_{D1}T_D}{\beta_D} \quad (3)$$

D Or D_D = 9.43 inch

Behaving the entire isolation system as a unit, required stiffness form corresponding to this period is:

$$T_D = 2\pi\sqrt{\frac{W}{g\times K_{D,min}}} \quad (4)$$

K_{eff} or K_H=588.50 kip/inch

Energy dissipated per cycle, $W_D=2\pi K_{eff}\beta_{eff}D^2$=49322.05 kip-inch.

The area of the hysteresis loop of the isolator; D_y is relatively small size so ignoring:

$$W_D = 4Q_d(D\text{-}D_y) \quad (5)$$

$$Q_d = \frac{W_D}{4D} = 1307.59 \text{ kips}$$

Post-elastic stiffness; K_d and D_y; $K_d = K_{eff} - \frac{Q_d}{D}$ = 449.84 kip/inch.

$D_y = \frac{Q_d}{K_u - K_d}$ and $K_u = 10K_d$ then we get; $D_y = \frac{Q_d}{9K_d}$ =0.323 inch.

The total cross sectional area of the lead plug area needed for the entire isolation system is:

$$A_{pb}(\text{total}) = \frac{Q_d}{F_{y(pb)}} = 871.73 \text{ inch}^2 \quad (6)$$

For the sake of simplicity, we keep the diameter of all isolators the same at Φ=30 inch. Using 4.25 inch diameter lead cores in 65 of the 81 isolators provides a lead cross sectional area of slightly more than 922.11 square inches. Now we have to re-calculate Q_d based on this new area of lead:

Q_d = 922.11*1.5 =1383.16 kips

The stiffness provided by lead plugs and the stiffness provided by lead plugs are,

$$K_{pb} = \frac{Q_d}{D} = 146.68 \text{ kip-inch} \quad (7)$$

$$K_{rubber} = K_H - K_{pb} = 441.8 \text{ kip-inch} \quad (8)$$

Rubber cross sectional area and required thickness,

$$T_{rubber} = \frac{GA}{K_{rubber}} = 6.5 \text{ inch} \quad (9)$$

Therefore, assuming 1.25 inch thick top and bottom end plates and steel shims, our isolators will have a height of less than 9 inches. Selecting a shape factor of S=10; Number of layer:

$$t = \frac{\Phi}{4s} = t = \frac{30}{4*10} = 0.75 \text{ inch} \quad (10)$$

$$N = \frac{6.5}{0.75} = 8.67 \text{ say } 9 \text{ layers} \quad (11)$$

IV.II SUPPORT PROPERTY DATA (ROTATIONAL INERTIA 1)

Isolator is a cylinder with diameter Φ=30 inch with height, h= 9.0 inch. Then cross section area, a= 706.85 inch^2. Behaving the entire isolation system as a unit, the required stiffness corresponding to this period is; K_{eff} or K_H=588.50 kip/inch. $I = \frac{K_{eff} * h3}{12E} = \frac{588.50*93}{12*14.51}$ = 49.042 inch4. Note that; young's modulus, E =0.01 ~ 0.1 Gpa. Assumed, E= 0.1 Gpa or 14.51 ksi.

$$D_y = \frac{Q_d}{9K_d} = 0.323 \text{ inch}$$

$$W = 0.241D2 - 0.0564D \quad (12)$$

[D ft]=0.00000296 kip
[M=0.00000136 kip.sec2/inch,] (17.5.3.5ASCE-4)

Using SAP2000 18, Define >Section Properties >Link/Support Properties >Add New Property;

IV.III SUPPORT PROPERTY DATA (DIRECTIONAL PROPERTIES; U1, U2, U3) AND NONLINEAR PROPERTIES

Effective stiffness = $\frac{A*E}{L}$ =1139.60 kip. Effective damping from the D_D =15 % [9].

Effective stiffness,K_{eff} or K_H=588.50 kip/inch. Effective damping from the D_D calculation =15 %, $D_y = \frac{Q_d}{9K_d}$ = 0.323 inch:

Stiffness = $\frac{\mu * w}{D_y}$ = 4681.11 kip/inch.

IV.IV GROUND MOTION DATA (EL CENTRO GROUND MOTION)

The ground motion data used in this work is a scaled version of the El Centro ground motion, which was the first major earthquake to be recorded by a strong-motion seismograph. It occurred in 1940, in the Imperial Valley in southeastern Southern California.

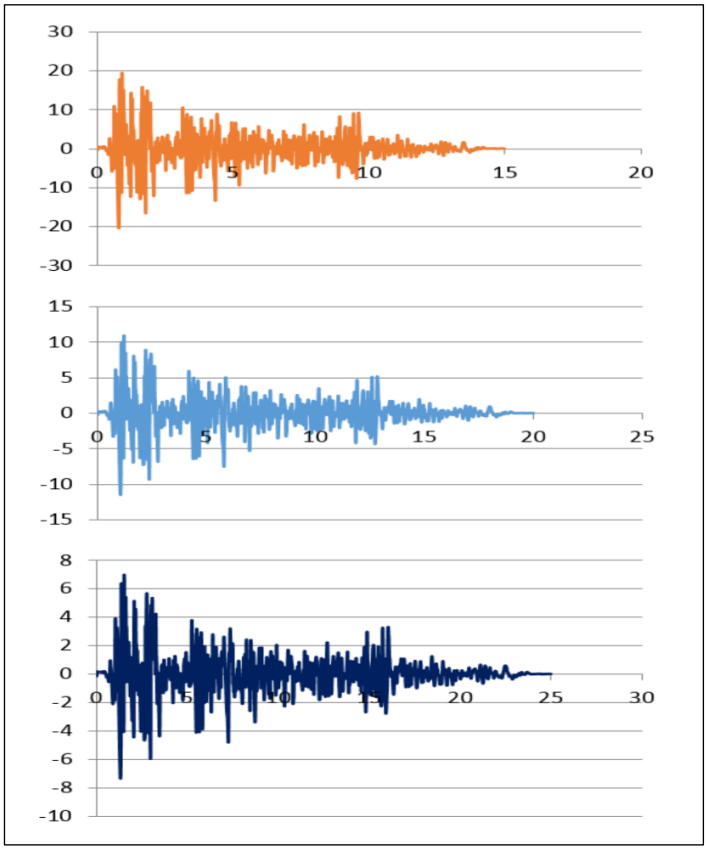


Figure 4: Acceleration vs. Time (Modified El Centro for 15, 20, 25 sec).
Source: Authors, (2020).

V. NUMERICAL ANALYSIS AND COMPARISON

SAP2000 18 nonlinear dynamic analysis is prepare and the comparison between bases isolated and not isolated building. Result for fixed supported building and base isolated building is described.

V.I NONLINEAR TIME HISTORY ANALYSIS

Time history function definition: Define > Function>Time history>Input file; Load case data: Define > Load case > Add new case > Time history.

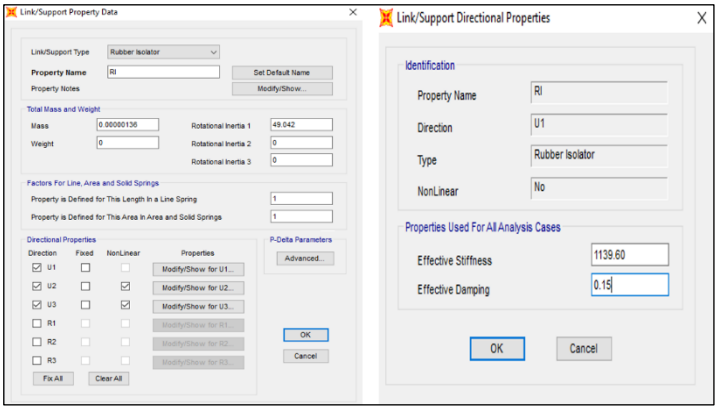


Figure 5: Link support properties.
Source: Authors, (2020).

Click the run for analysis. After analysis we get the displacement from. Display > Plot function > Displacement for time history at maximum time.

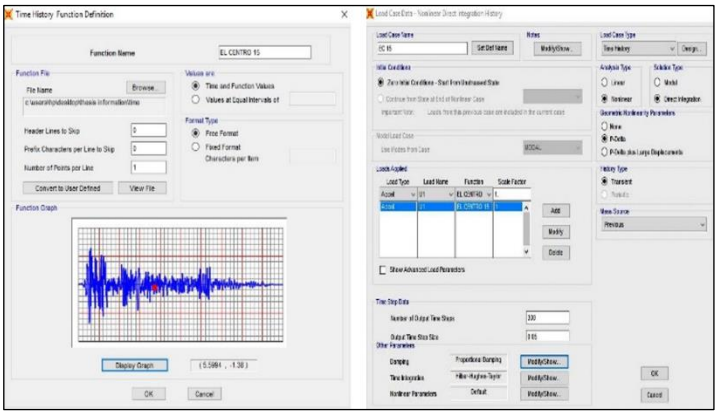


Figure 6: Time history function.
Source: Authors, (2020).

From SAP2000 18 analysis displacement vs. time; acceleration vs. time curves are found and comparison between top and bottom floor displacement vs. time; acceleration vs. time curves. The top floor displacement vs time curves with and without base isolation for 15, 20, 25 sec.

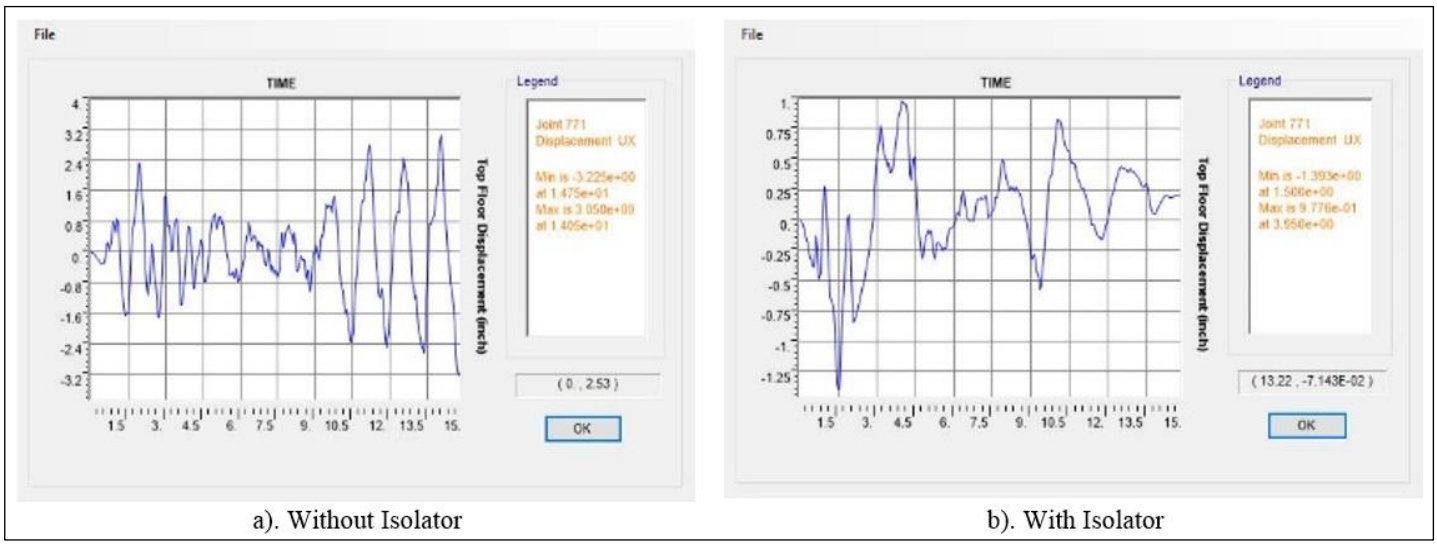
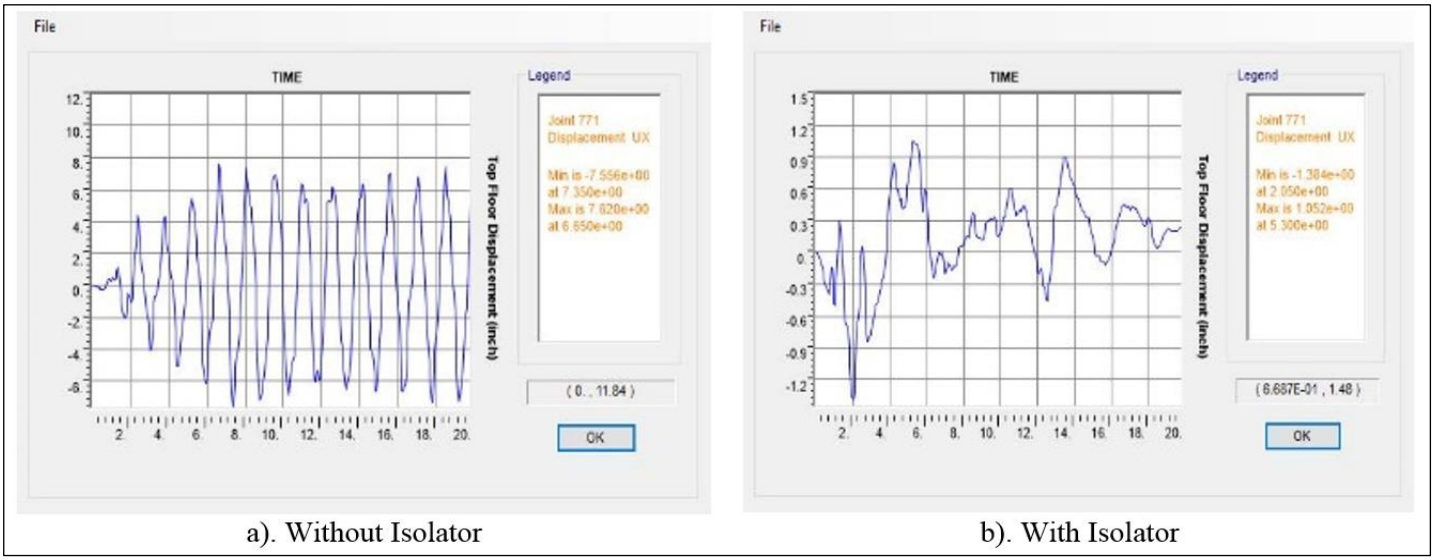
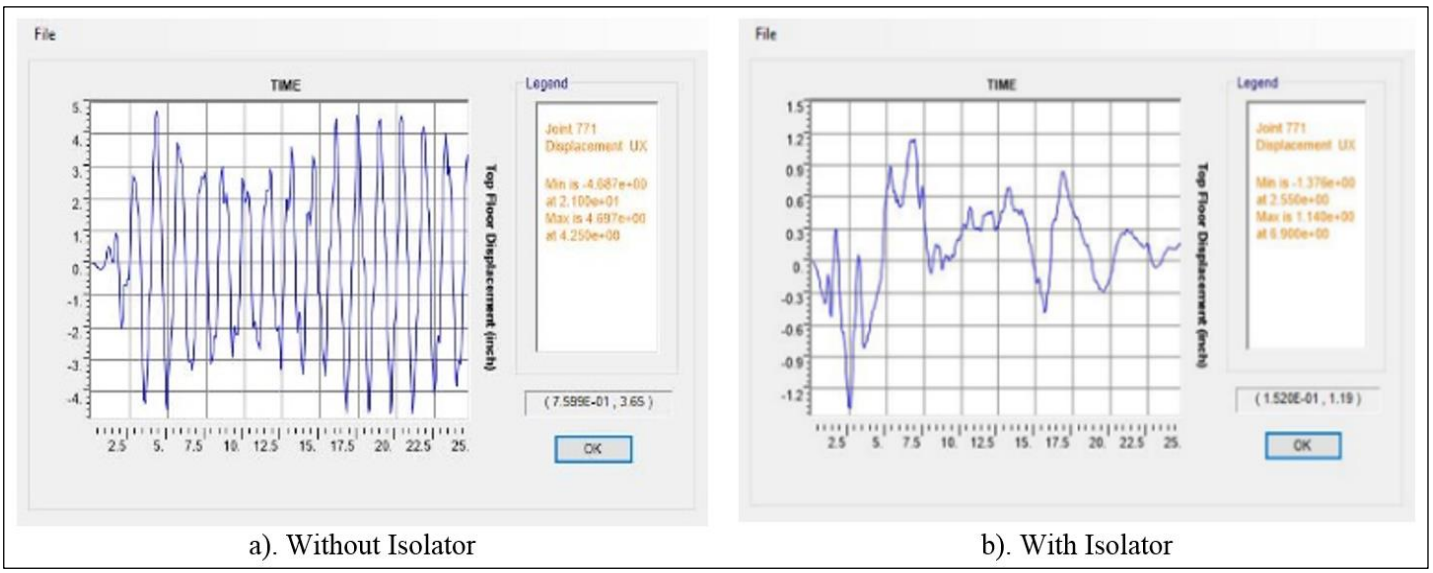


Figure 7: Top floor displacement vs time curve (15 sec).
Source: Authors, (2020).



a). Without Isolator b). With Isolator

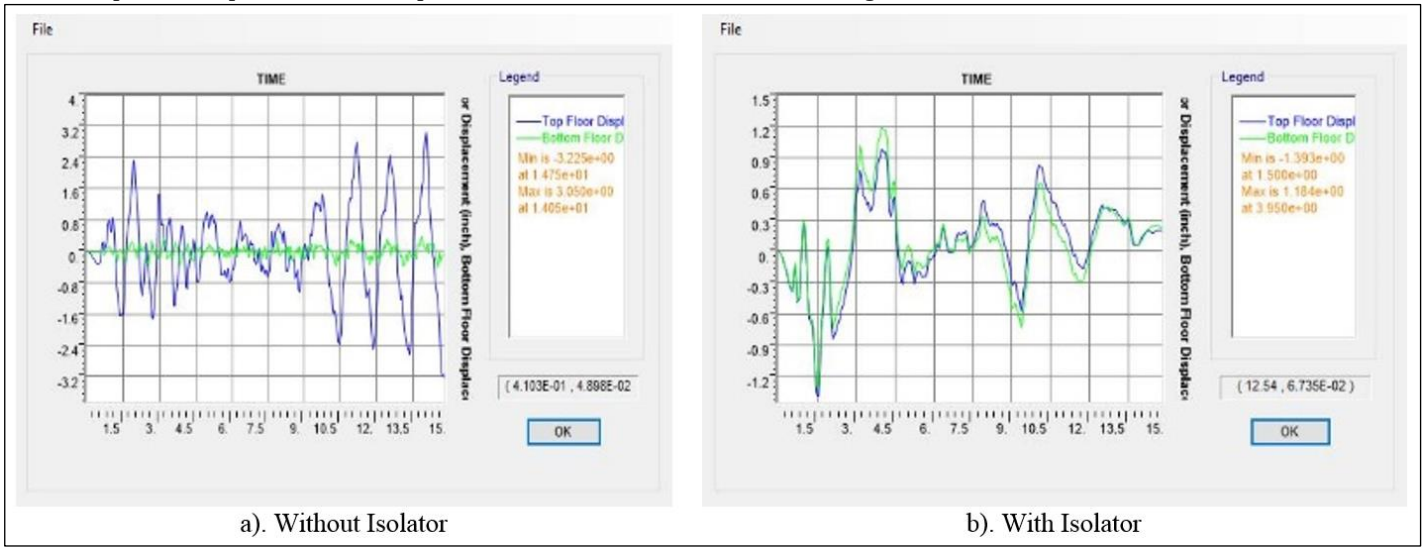
Figure 8: Top floor displacement vs time curve (20 sec).
Source: Authors, (2020).



a). Without Isolator b). With Isolator

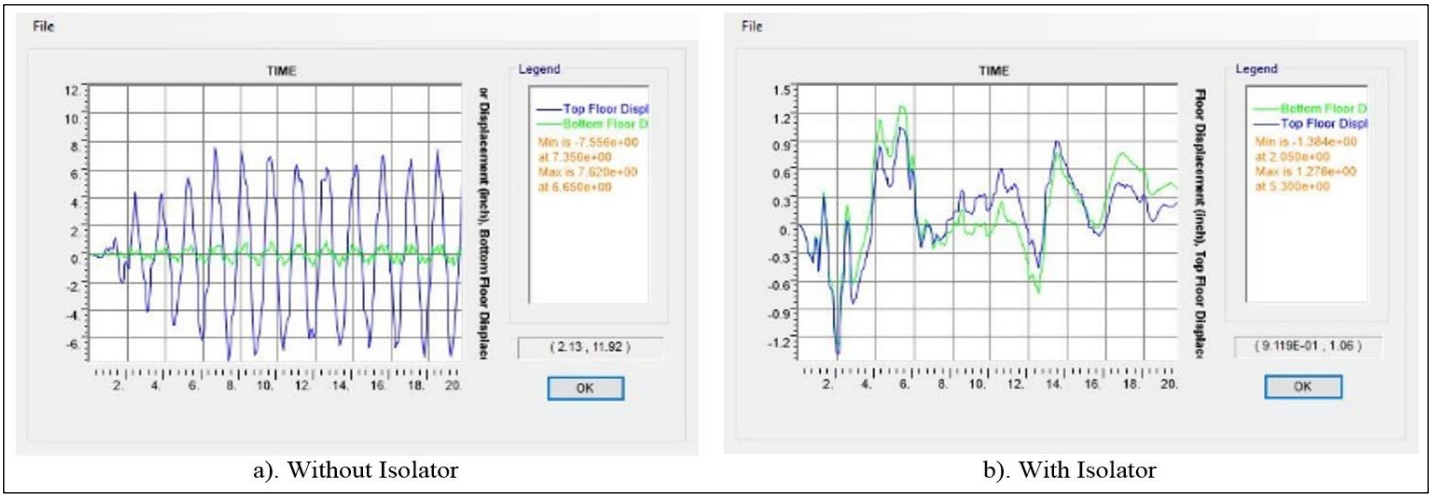
Figure 9: Top floor displacement vs time curve (25 sec).
Source: Authors, (2020).

Comparison Top and Bottom Displacement vs. Time Curves for El Centro ground motion 15, 20, 25 sec.



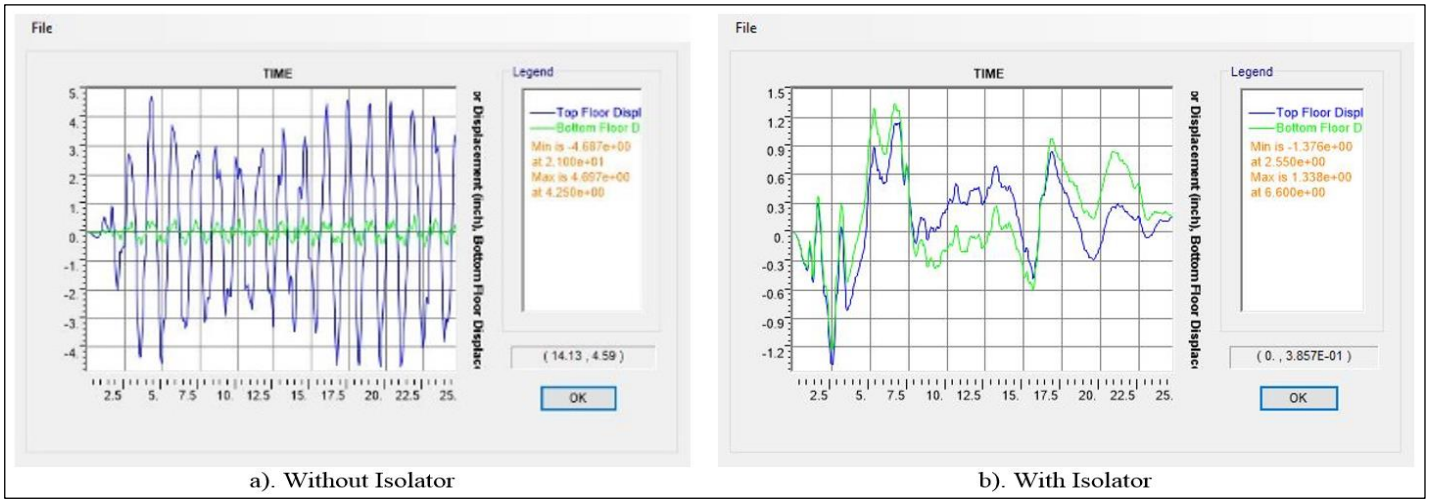
a). Without Isolator b). With Isolator

Figure 10: Top and bottom displacement vs time curve (15 sec).
Source: Authors, (2020).



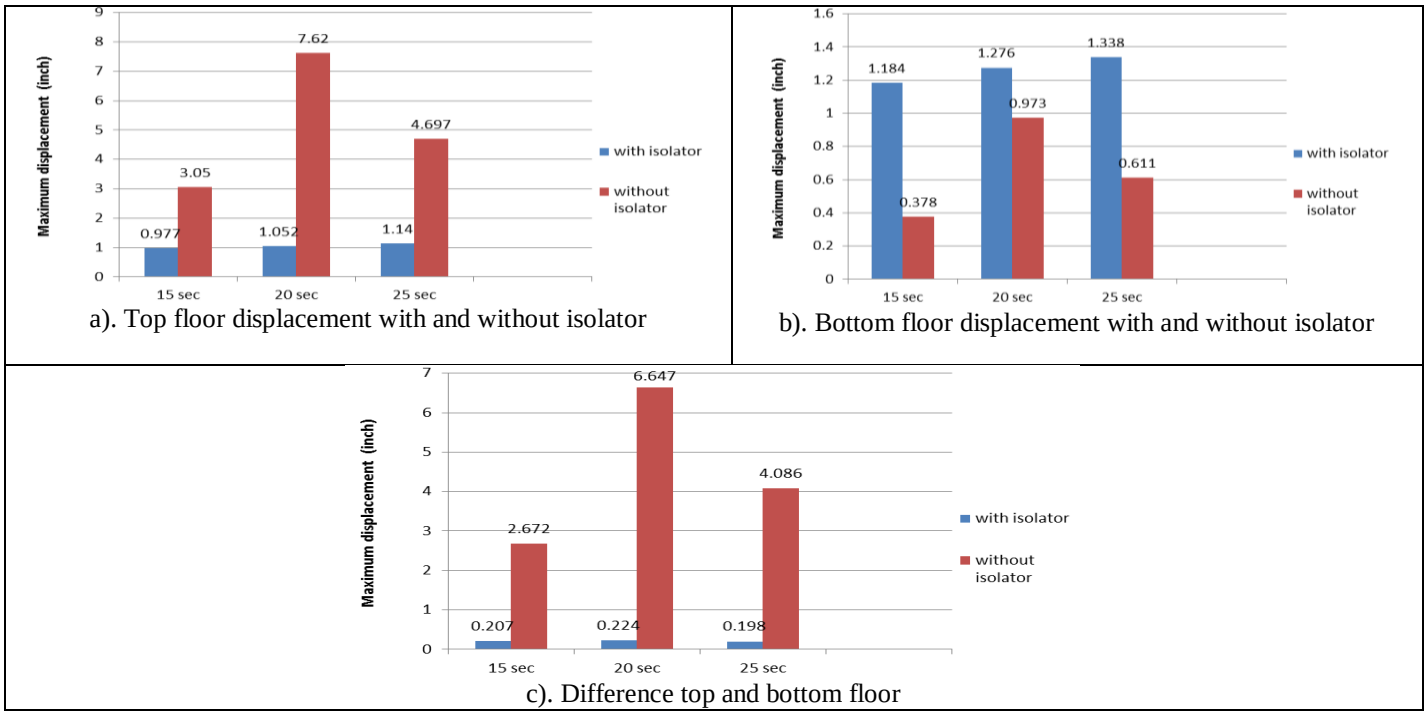
a). Without Isolator b). With Isolator

Figure 11: Top and bottom displacement vs time curve (20 sec).
Source: Authors, (2020).



a). Without Isolator b). With Isolator

Figure 12: Top and bottom displacement vs time curve (25 sec).
Source: Authors, (2020).



a). Top floor displacement with and without isolator

b). Bottom floor displacement with and without isolator

c). Difference top and bottom floor

Figure 13: Displacement variation with and without isolator for different EL centro data.
Source: Authors, (2020).

Table 2: difference between top floor and base floor displacement of model for different El centro data.

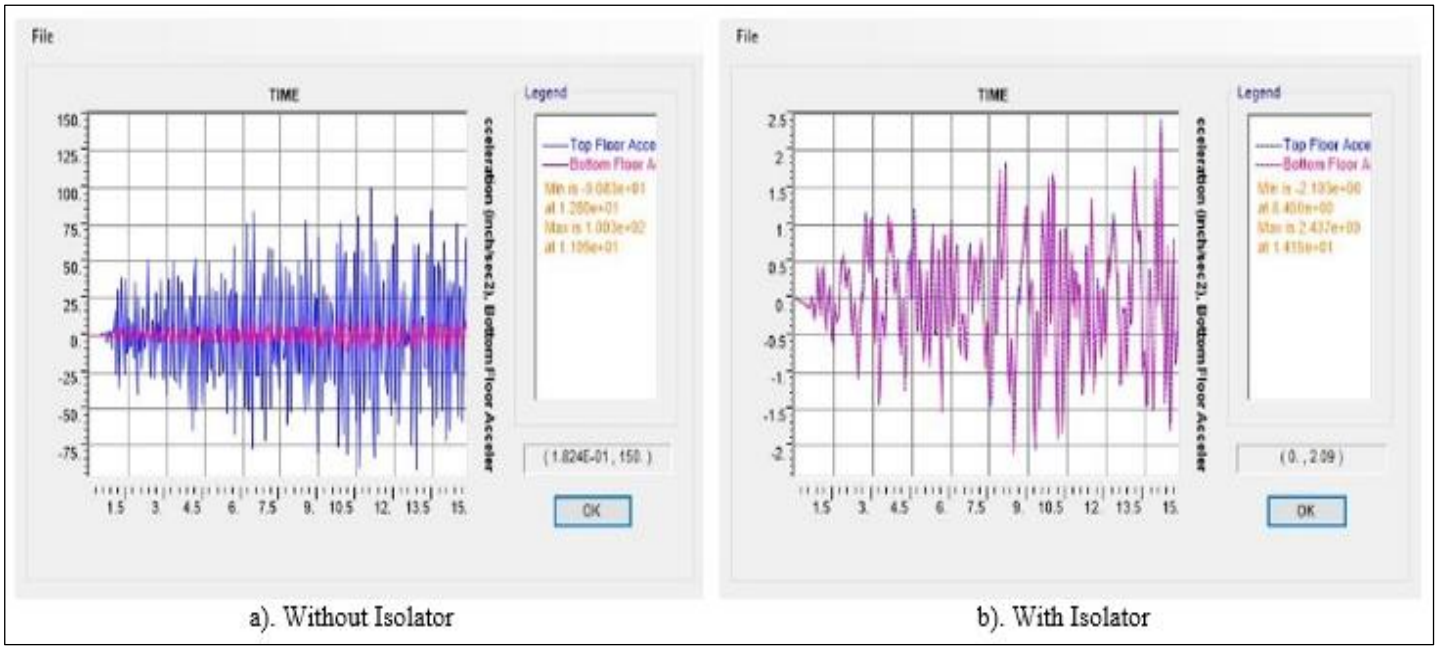
time (sec)	with Base Isolation (inch)				without Base Isolation (inch)			
	Top Floor		Base Floor		Top Floor		Base Floor	
	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
15	0.98	1.39	1.19	1.32	3.05	3.23	0.38	0.41
20	1.05	1.39	1.28	1.28	7.62	7.56	0.97	0.87
25	1.14	1.38	1.34	1.22	4.69	4.69	0.61	0.52

Source: Authors, (2020).

Table 3: modal participating mass ratios.

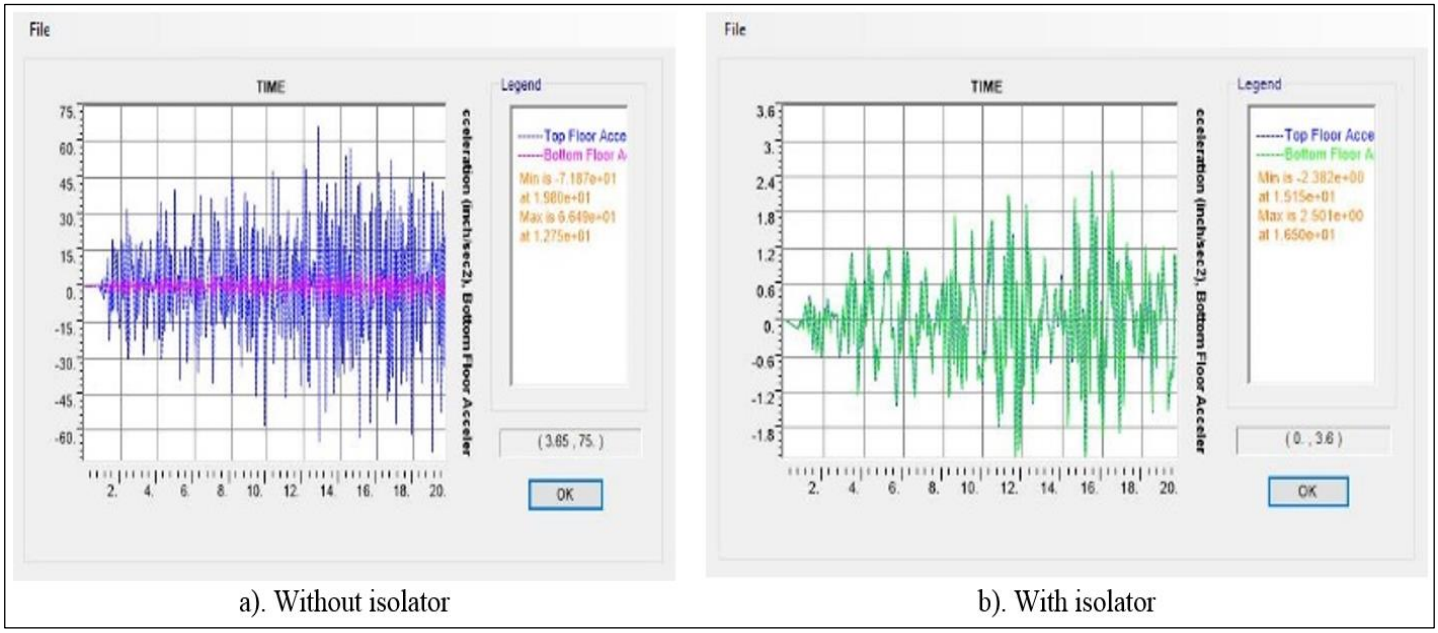
Output Case	Step Type	Period	Sum UX	Sum UY	Sum UZ
Text	Text	Sec	Unit less	Unit less	Unit less
MODAL	Mode	1.741249	0.85	0.006458	2.22E-08
MODAL	Mode	1.664218	0.87	0.71	0.000000421
MODAL	Mode	1.555428	0.89	0.89	4.213E-07
MODAL	Mode	0.548855	0.96	0.89	6.053E-07
MODAL	Mode	0.526091	0.96	0.95	0.000004552
MODAL	Mode	0.491833	0.96	0.96	0.000004559
MODAL	Mode	0.300586	0.98	0.96	0.000004752
MODAL	Mode	0.218247	0.98	0.96	0.000004774
MODAL	Mode	0.175874	0.99	0.96	0.000006694
MODAL	Mode	0.09474	0.99	0.96	0.000007226

Source: Authors, (2020).



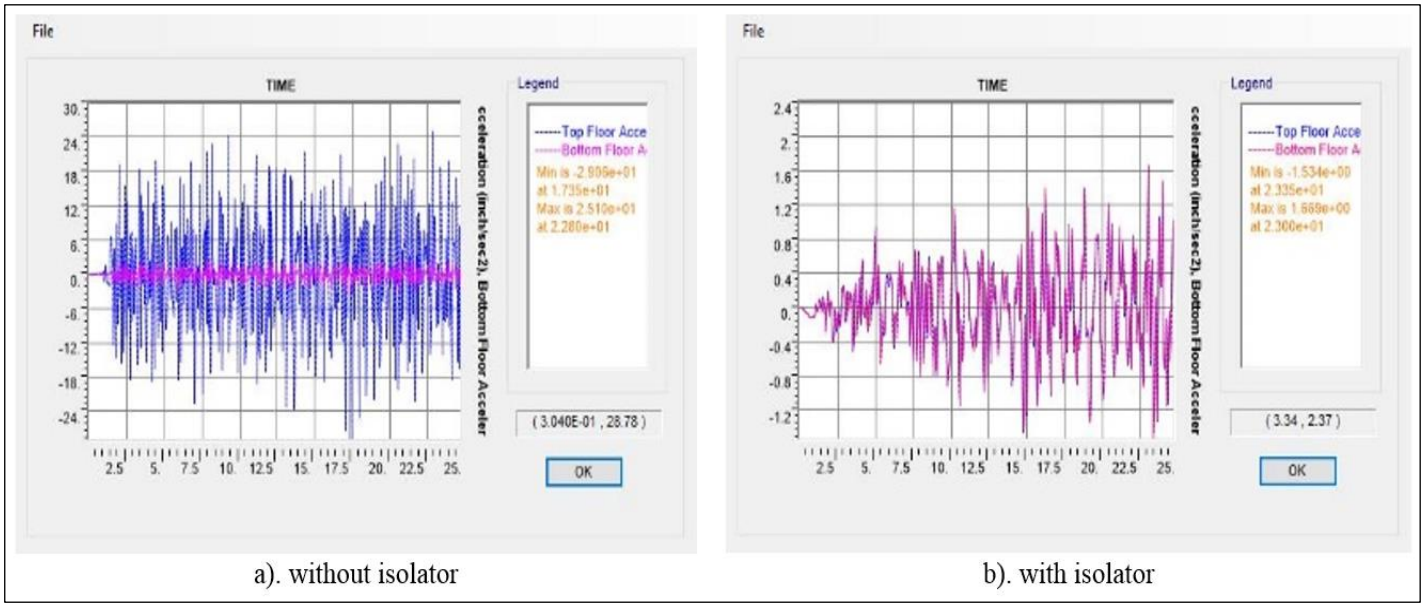
a). Without Isolator b). With Isolator

Figure 13: Top and bottom acceleration vs time curve (15 sec).
Source: Authors, (2020).



a). Without isolator b). With isolator

Figure 14: Top and bottom acceleration vs time curve (20 sec).
Source: Authors, (2020).



a). without isolator b). with isolator

Figure 15: Top and bottom acceleration vs time curve (25 sec).
Source: Authors, (2020).

VI. CONCLUSIONS

Numerical design of lead rubber bearing and applying lead rubbing bearing as a isolator of multi storied building in Dhaka. Development of working knowledge on SAP2000 18 and its application in the nonlinear dynamic analysis of multi storied building structures and it shows how a multi-storied building act as a base isolation building. The main comparison is among the displacements and accelerations found of the building in two condition (without base isolator and with base isolator) using SAP 2000 18 nonlinear dynamic analysis, the results show for base isolated building shows it can take more displacement than the building which is not base isolated. By comparing displacement vs time, acceleration vs time graphs for base isolated and non-isolated building, the displacement difference between top and bottom floor is almost close that indicates this building structural behavior better during earthquake load.

VII. SUGGESTIONS

Seismic isolation (SI) and the other anti-seismic (AS) systems have already been widely used in over 30 countries and their application is increasing more and more, for both new constructions and retrofits, for all kinds of structures and their materials. The features of the design rules used, as well as earthquake lessons, have plaid a key role for the success of the aforesaid technologies [10, 11]. The designers are allowed by the code to decrease the seismic forces acting on the superstructure when adopting this technology. Use this technology these things are require,

1. A reliable definition of the seismic input, i.e. by means of intensive use of Neo-deterministic seismic hazard assessment (NDSHA).
2. Careful selection, design, manufacturing, installation, protection and maintenance of the Seismic isolation (SI) devices during the entire life of the isolated structure;
3. Particular attention to be also paid to some further construction aspects (in particular, to the design, realization, protection and maintenance of the structural gaps and the safety related pipelines – e.g. the gas ones – again during the entire life of the isolated structure).

VIII. AUTHOR'S CONTRIBUTION

Conceptualization: Al Amin, Mufedul Islam.
Methodology: Al Amin, Mufedul Islam and Md. Jobaer Ahamed.
Investigation: Al Amin, Mufedul Islam and Md. Jobaer Ahamed.
Discussion of results: Al Amin, Mufedul Islam.
Writing – Original Draft: Al Amin.
Writing – Review and Editing: Al Amin, Mufedul Islam.
Resources: Mufedul Islam.
Supervision: Al Amin, Mufedul Islam and Md. Jobaer Ahamed.
Approval of the final text: Al Amin, Mufedul Islam and Md. Jobaer Ahamed.

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RESEARCH ARTICLE OPEN ACCESS

LEAN CONSTRUCTION AS A PANACEA FOR POOR CONSTRUCTION PROJECTS PERFORMANCE

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ABSTRACT

Recurring problems in the delivery of construction projects have been time and cost overruns, poor quality, poor health and safety, waste and loss of value. This situation is worsened by the reluctance of construction organisations to fully implement lean construction technique which has proved to be an innovative solution to these problems. This study assessed construction professionals' perception of the awareness, adoption and benefits of lean construction in remedying poor construction project performance in the south-south region of Nigeria. A well-structure questionnaire distributed by hand and electronically using the snowball sampling technique were used to gather data from the participants from both the private and public organisations. Frequency, percentage and factor analysis were used to analyse the collected data. It was found that the level of awareness of lean construction is high but it s adoption is low. Lean construction is a panacea for poor construction project performance because of it s cost related benefits, value and relationship benefits, environmental benefits, quality improvement benefits, motivation and productivity benefits, profitability and market benefits, time and work flow benefits, waste reduction benefits, and HS and rework reduction benefits. The creation of dedicated department/team for driving the lean initiative is recommended.

I. INTRODUCTION

Globally, the construction industry has proven to be of great benefits to national economic growth and development. Its impacts are evident in various forms of building and infrastructural provisions, employment generation, wealth creation, and contributions to national income. According to the submission of [1] and [2], the construction sector is one of the critical industries in both developed and developing economies that contribute significantly to economic growth. The industry has however, been faced with numerous challenges which according to [3], have tried to limit its contribution to sustainability and effectiveness in providing clients' value for their monies and end-users satisfaction. Furthermore, the industry is heterogeneous in character with different project types that are constantly being confronted with a lot of ambiguity in design and planning, multitude of stakeholders with varying interest, resources availability, environmental variables, economic condition and legislations and regulatory requirements [4]. The slow and sluggish nature of the key stakeholders of the industry in the uptake and adoption of innovative techniques, technologies and concepts like lean construction, has been blamed for its inefficiencies that have led to poor project performance and delivery issues [5-9]. Also, the implementation barriers to lean construction at the initial stages of project is due to the absence of suitable evaluation tools that would enable companies determined the true value of lean construction [10].

The lean construction have proven to be an innovative practice to improving project delivery and performance in the area of time, cost, quality, waste generation, clients and end-user satisfaction. According to [11], lean construction is an innovation tool for efficiently managing construction projects as well as

minimising wastes and enhancing performance. Similarly, in South Africa, [4] also found that the key impacts of lean construction on construction projects are waste minimisation, efficient materials administration and improved whole-life cost. The lean construction practice offers a value added technique for designing, managing, construction projects to improve time and workflow performance, efficient resource utilisation, waste elimination, with the overall maximisation of value for clients' monies [12-13].

In Nigeria, construction projects delivery are known to be suffering from a lot of setbacks as evident in the submissions of [14-16]. It was submitted that building construction projects are characterised by poor quality, cost and time overruns. These problems have contributed greatly to the decline in profit margin being experienced in the Nigerian construction industry; this is in spite of the ever increasing demand for housing and other infrastructure of general nature [17]. More worrisome are the issues of poor productivity and performances in terms of time, cost and quality [12]. A suitable measure for ameliorating the problem is the adoption of lean construction practice. Although, maximization of the full benefits of lean construction is jeopardized by the level of adoption of the lean conept which is still at the infancy. The concept is however, gradually gaining wider awareness among professionals, alt hough, the adoption is still low in the construction industry [3].

A review of studies on lean construction practice in Nigeria shows that researchers and academics have adopted a single state as there study area. For instance, [13] assessed lean construction practice among construction professionals in Ondo State, and recommended for an extended study that would cover a wider area and locations. [12] assessed the prospects and challenges of lean construction practices among architects in Lagos State, and recommended for a similar study to evaluate the perception of other construction professionals in other areas. Port-Harcourt is among the five states considered in the study of [3]; Port-Harcourt is just one of the 6 states that made up the south-south region of Nigeria. There is no known study on lean construction that has covered the entire south-south geo-political zone of Nigeria. These region houses the six key oil producing states of Nigeria and particularly the Niger-delta region of the country. [18] submitted that majority of the construction firms operating in the Niger delta regions of Nigeria are SMEs and the size of these firms exerts a significant influence on the level of adoption of sustainability practices in the Niger Delta. The lean construction techniques have a link with sustainability practices as indicated in the report of [19]. It was reported that lean and sustainable constructions have considerable commonality which include cost savings, waste minimization, Jobsite safety improvement, reduced energy consumption, and customers' satisfaction improvement. It is based on these that this study titled 'lean construction as a panacea for poor construction projects performance', is carried out. To achieve this purpose, the study assessed construction professionals' perception on the awareness, adoption and benefits of lean construction in remedying poor construction project performance in the south-south region of Nigeria. The study also offered recommendations for improving the practices of lean thinking, for better project performance and delivery.

This study adds to existing body of knowledge on lean construction globally and particularly to the few available studies on lean concept in Nigeria. Construction organisations and other stakeholders will be encouraged to adopt this innovative technique that has proven to increase profit generation, waste reduction and client satisfaction. In addition, it's a step towards meeting the economic, social and environmental dimensions of sustainable construction needs of Nigeria, and by extension other developing countries.

II. LITERATURE REVIEW

II.1 THE CONCEPT OF LEAN CONSTRUCTION

Bajjou et al.[20] and Sarhan et al. [1] states that the origin of lean construction philosophy that is practiced in the construction industries of countries can be traced to the lean concept of the manufacturing sectors, and particularly from the Toyota production system. Egan [21] reported that the adoption of lean philosophy in construction was based on the successes recorded by the manufacturing sector for implementing the lean principles and the resultants benefits therein. One of the early authors who made efforts to introduce the lean thinking in the construction industry was [22]. In the Stanford report by [22], contains the discussion of the applicability of what was called 'the new production philosophy'. Ever since it was introduced to the construction industry, after it was first introduced to manufacturing by Toyota motors, the concept of lean construction have successfully been adopted globally in the construction industry [23]. The Lean concept is a philosophical tool of management that focuses on finding and eradicating wastes from the whole process of production value chain [24]. It is not only applied on production organisations but also along the chain of supply and implementation. Lean construction according to [25] is a technique of designing the production systems to focus on material waste and time reduction and to maximize value. This definition by [25] is not different from the main philosophy of lean objective in manufacturing. The main objective of lean manufacturing is waste minimisation and value maximisation. In the same vein, lean construction was defined by [26] as a systematic approach adopted to improve value for customers through identifying and excluding waste through a repeated process of enhancement in the quest for excellence. Hall [27] defined lean construction as a philosophy adopted by the construction team that involves the practices and technologies that decrease costs, materials, time and effort, that are specific to the project at hand. Therefore, the principles and concepts of lean construction is aimed at making construction project delivery and management focus on waste elimination for value maximisation and project success.

II.2 LEVEL OF AWARENESS AND ADOPTION OF LEAN CONSTRUCTION TECHNIQUES

The adhesion of other improvement processes of an organisation have made it impracticable to implement lean construction in the construction industry of Brazil [10]. The investment evaluation and benefits assessment are key requirements prior to adoption of the lean construction principles [28]. The requirements and efforts involved in the benefits assessment and investment evaluation have grossly been misinterpreted as a weakness [10].

In the UK, [29] and [30] reported that more than two decades after Egan report was published, the implementation of the lean construction practices was still limited, and according to [6], the situation was attributed to structural and cultural barriers. In an earlier study by [7] in Germany, low level of awareness of

the lean techniques was reported. In the USA and India, successes have been recorded in reducing waste and making profit from the actual implementation of the lean methods in construction projects [31]. The study found that although the implementation is high, the participants were not awareness that they were using a lean techniques in minimising waste and maximising profit.

In the Ghanaian construction industry, there is a good level of awareness, but with a low familiarity and application level of the lean construction concept among construction practitioners [32]. Later studies by [33] in Turkey, and [34] in Ethiopia, indicated low level of awareness of lean construction techniques among practitioners in the construction industries of the countries. [11] in Morocco found that, although, the level of adoption of lean construction practice is low, its awareness among professionals is high. Wandahl [35] reported that 3 out of 4 practitioners do not know about lean construction practices, and this situation was blamed on lack of knowledge, education and communication on the importance of the lean concept.

In a study carried out by [3] in five cities from the five geo-political zones of Nigeria, it was found that the level of awareness of lean thinking is improving but there is a comparatively low level of adoption among construction firms. In a study carried out a decade earlier by [36], it was reported that the level of awareness of lean construction technique is low among construction stakeholders. However, [13] reported that a larger number of the construction professionals are aware of the term lean construction and its techniques. Similarly, according to the study of [12], 89% of the Architects sampled are well informed of the lean construction techniques.

II.3 LEAN CONSTRUCTION PRINCIPLES

Banna [37] submitted that the number of construction firms that have embraced the lean methodology is growing because of its emphasis on value maximization for customers and waste minimization. In addition, the lean methodology is mostly suitable for industry where cost, time and safety are critical. Although, lean construction practices are simple and attractive, its methodology of project delivery is different from the conventional methods. This has made the proper implementation of the lean philosophy and techniques challenging.

The model in which the lean construction are executed is different, the lean model operate in such a way that projects are managed to align with deliverying true value to clients [38]. It involves a continuous monitoring which provides the project team and field operatives with an opportunity for improvement and reduce waste, as well as keeping the line of communication clear and ensuring seamless flow of works, timely completion, and making sure that customers' requirements are met with zero delays and discrepancies [38].

There are building blocks and/or guiding principles that help organisations reduce construction cost, time, material waste, labour cost, and improve productivity and efficiency. [37-40] identified six principles and they are; identifying value from the client's viewpoint, implementing processes that deliver true value, eliminating waste at every point possible, achieving a collaborative and continuous workflow from start to finish, using pull planning and scheduling for a streamlined approach, and continuous monitoring and optimisation. The successful implementation of these lean principles is a key to cost cutting, construction time reduction, productivity improvement and efficiently managed projects [40]. Furthermore, these principles drives and guide key industry players in developing tools and methods to aid the achievement of the lean construction goals and holistic approach to the delivery of projects.

II.4 BENEFITS OF LEAN CONSTRUCTION TECHNIQUES

A lot of countries have realised the importance of lean construction and now adopt it for better performance and delivery of construction projects. The interest in lean construction approach may not be unconnected to the various problems associated with the conventional system of building construction delivery. Shang and SuiPheng [41] states that time and cost overruns have remained recurring problems inherent in construction and engineering fields. Furthermore, construction projects according to [20] are characterised by poor quality, poor health and safety performance, and negative environmental effects.

Construction organisations that adopt lean construction are preparing themselves against the future. According to [27], contractors who adopt lean construction as part of their strategic plan, are preparing themselves for both the present and the future. [27] further identified five elements that guide the lean thinking philosophy, and they are shorten construction time, reduced cost, accelerate activities, improved planning and improve process control.

Kane [42] posits that the benefits of construction techniques include; improve the health and safety on site, streamlining of construction processes to ensure quicker and efficient working. This will help to reduced product waste, time waste, energy waste and money waste. Tasks are finished faster, thus, leading to cost savings. The efficient working which the lean construction technique leads to, helps in time savings and labour cost reduction. [43] states five reasons why building lean is beneficial, and these are meeting the industry demands, maximizing efficiency, reducing safety hazards, decreasing waste, and valuing relationships.

[44] in South Africa found that the top five benefits of lean construction practices are reduction of waste, effective administration of materials on site, improved life-cycle cost, greater client satisfaction, and good project coordination. [45] had earlier reported that the most importance benefits of lean construction are waste reduction and value achievement throughout the entire construction process. [46] highlighted seven points that enhances the view of lean construction, these points are; continuous improvement in construction industry, focus on smart work through companies management rather than hard work by adopting strategic plans for future, reduces waste production in the field which is useful in increasing the profit, reduces the cost of the project, increase in customer satisfaction, better and smooth communication among parties and increases in productivity.

From the study of [13], the major benefits of lean constriction practices are; improvement of project delivery methods, more satisfied clients, delivery of products or services that enable clients to better accomplish their goals, promotion of continuous improvement in project delivery methods through lessons learned, and minimization of risk and maximization of opportunities. In Sweden, [47] found that lean principle has the potential for improving planning process for maintenance contracts, even though, the effective application is limited by contractors' lack of knowledge. According to [48], lean-based tools have successfully been applied to both simple and complex construction projects in Egypt, and the result have shown that

lean-based construction projects are managed better and easier, have better safety performance records, completed earlier than planned, cost less and have better quality performances. In a separate study in Egypt, it was reported by [49] that lean technique implementation play a critical role in reducing the entire duration of an industrial project by 15.57%.

In the Moroccan construction industry, [11] found that the major benefits of adopting lean construction approach in order of mean weighting are; better project quality, improving safety, Improving the environmental performance, reducing overall project duration, and reducing construction cost. It was further submitted that construction practitioners recognised that lean construction helps to achieve the non-financial performance of construction projects. In Iran, it was concluded that the performance of construction projects in which lean approach was applied is better than that in which the traditional process was used [50]. In the South African Construction Industry, construction professionals opined that the major benefits of lean construction are; reduced waste, efficient administration of materials, improved whole-life cost, improved customer satisfaction, improved safety, and increased productivity [4]. In the Swedish construction industry, a case study of large construction organisation revealed a reduction of the project cost by 1.25% by increasing the added value from 40% to 45% [51]. After incorporating lean construction principles, the total duration reduced by 6.15% -9.56%; this was the finding of [52] in Turkey, who compared a residential building project with lean and non-lean scenarios using a Monte Carlo simulation.

It was reported in the USA that, a parking-garage project was completed 3 weeks ahead of schedule, within proposed budget and with negligible quality defects; as a result of the application of lean construction tools [53]. A study by[54] in the USA, showed that the application of kaizen activities in housing lead to a 50% saving in costs. In the USA, [55] combined the lean concept with safety analysis approach in a case study of modular housing plant, and found that safety risks such as trip hazards from excess cords and fatigue from less walking were reduced. This study revealed a decline in accidents and injury, thus, implying an improvement in employees safety. Similarly, in an earlier study by [56] in the US, an analysis of responses from 62 homebuilders who used continuous improvement programs of the lean concept, revealed a significant decline in fatalities and accidents rates when compared to builders who does not apply any of the continuous improvement programs. Thus, this shows that there is a relationship between the adoption of lean construction techniques and improvement in workforce safety.

[31] broke down the benefits of implementing Lean concept into three groups, and they operational improvements, administrative improvements, and strategic improvements. Under the operational improvement, the key benefits are; reduced lead time (cycle time), increased productivity, reduced work-in-process inventory, improved quality, and reduced space utilisation. Example of benefits under the administrative improvements are; reduction in processing errors, reduction of paper work, reduction of staff demands, reduction of turnover and the resulting attrition costs, engagement of highly performing professionals, and streamlining of customer service functions so that the customers are no longer placed on hold. The strategic improvements benefits are; help successful companies to improve their market share, time delivery of goods and services to customers are reduced, more sales, repeat patronage, increased in company's revenue, profit and cash flows [57]. A study that adopted three case studies from Brazil, Ecuador and Nigeria, established that the benefits of lean construction to affordable housing projects are; increase the production efficiency, reducing losses, improved product quality and improving productivity, which produced a direct impact on time reduction, materials and labour savings and profitability [17].

Lean construction has shown successful results with complex, uncertain and quick projects [53]. It is claimed that in emerging economies, the implementation of lean construction techniques on construction projects have led to benefits such as; more satisfied clients, productivity gains, greater predictability, shorter construction periods, design improvement, less waste and reduced cost [58, 30]. According to [11], more developing countries have started adopting the lean construction philosophy in recent years. This is because of its objective of minimising waste, maximising value to the clients, keeping to deadlines and budgets, improving staff safety and reduction of the harmful effects of construction activities on the environment. The importance of adopting lean construction techniques on construction projects according to [59], are maximise the use of multi-skilled workforce, improve communication effectives among stakeholders, encourage collaboration, productivity improvement, waste reduction, better quality of work, time savings, and employees are encouraged to think lean.

III. MATERIALS AND METHODS

This study was carried out to establish that lean construction is a panacea for poor construction projects performance. The approach of investigation was a questionnaire survey of construction professionals' perception on the awareness, adoption and benefits of lean construction in remedying poor construction project performance in the south-south region of Nigeria. The questionnaire is useful where the study requires covering of wider areas within a shorter time and at an economical cost. It brings objectivity to research by allowing for quantifiable outcome [60]. The questionnaire was design into three parts. The first part gathered data on respondents' basic personal and organisational information. Data from this first section served as a quality check to data from other sections of the questionnaire. The second part collected data on the level of awareness and adoption of the lean construction principle. The third part gathered information on the benefits of lean construction. Target respondents were asked to rate the 41 benefits of lean construction selected from literature review; in accordance to the level of importance in remedying poor construction performance from their experiences, using a Likert scale of 1to5 (where 1 is the lowest and 5, the highest scale). In order to obtain quality and unbiased data, construction professionals who are knowledgeable about the lean concept, currently engaged in an active construction site, and have at least 5 years of working experience within the study region were sampled. These professionals are Architects, Builders, Engineers and Quantity Surveyors. They were chosen because they form bulk of the professionals engaged by construction organisations whether in the public and/or private sector. The population of these professionals within the study area is 1252 (Akwa Ibom =214, Bayelsa state =128, Cross River =223, Delta =200, Edo =237, Rivers =250) [18]. Using [61] sample size determination table, the samples size of 197 was obtained.

The survey of the professionals was conducted using the snowball technique. A preliminary survey led to the identification of some target respondents who met the study sample selection criteria. This is because it was impracticable to get the exact

number of the target professionals with the set years of experiences and that were actively involved with a construction site during the period of this study. The snowball sampling is dependent on referral [62], and can significantly increase the study sample size [63]. Furthermore, due to the wider study area, this study adopted personal delivery of the questionnaire and by electronic means. This is to further reach a larger audience, at a shorter time and economical cost. The electronic means reduces the volume of papers involved; thus, saving the forest (i.e. is it an environmentally friendly means of survey). At the end of the survey, 161 useable responses were collected from professionals that met the study selection criteria. The retrieved responses represent a response rate of 81.73%, and this was deemed adequate for the analysis. This higher return rate could be attributed to the survey period of 14 weeks and follow up calls to some select participants.

The gathered data was first subjected to a reliability evaluation using Cronbach alpha test. An alpha value of 0.933 was obtained for the variables on the benefits of lean construction. This shows that the questionnaire used is reliable, and the data are of good quality. A normality evaluation was carried out to ascertain data nature and distribution using Shapiro-Wilk test. The Shapiro-Wilk test is suitable for samples that are below 2000 according to [64]. The result obtained shows that data gathered were non-parametric in nature. Frequency and percentages where used to analyse the data gathered on the respondents' basic personal and organisational information, the level of awareness and adoption of lean construction. Kruskal-Wallis H-Test was further used to determine the difference in the perception of the professionals regarding the rating style of the variables gathered on the benefits of lean construction, and in establishing the proportion of the variables where the views differs significantly. This test was conducted based on the understanding that since these professionals are from different states, different organisational background and experiences; there is tendency to have differing opinion regarding the variables of the questionnaire. The Kruskal-Wallis H-Test is suitable for determining the difference in the opinion of three groups and above. In addition, the non-parametric nature of the data justifies the use of Kruskal-Wallis H-Test. Factor analysis (FA) using principal component analysis (PCA) with varimax rotation was used to analyse the data on the benefits of lean construction. The aim is to group the variables into manageable, cohesive proportion of different constructs. Prior to the actual FA, its suitability was justified by an examination of the communalities, Kaiser– Meyer–Olkin (KMO) and Bartlett test of sphericity. The use of FA is one of the gap identified from extant studies. Existing studies on lean construction utilised mean analysis, relative importance index (RII) and percentages in their analyses. The entire analysis is summarized in the flow chart below (Fig.1).

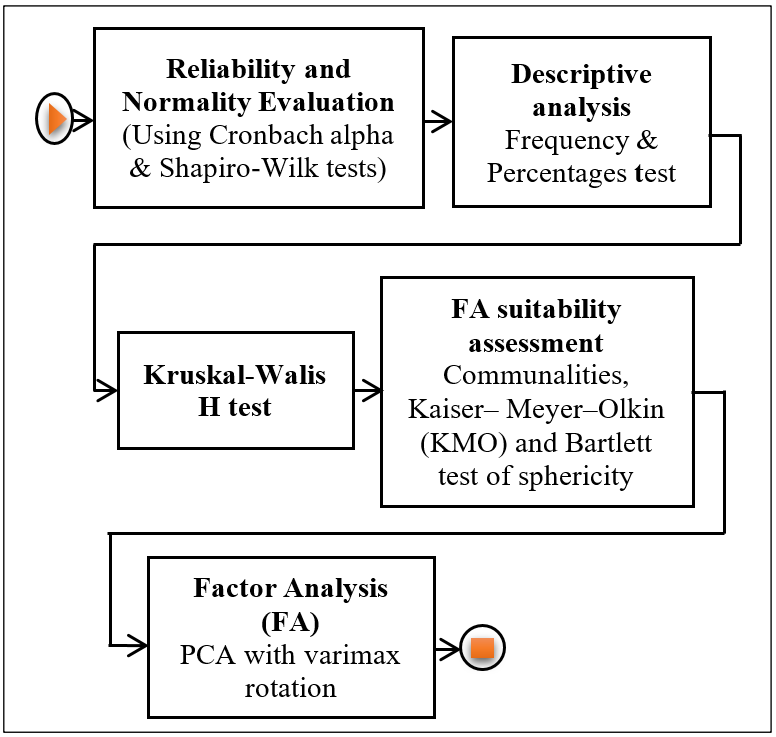

Figure 1: Data analysis flow chart.
Source: Authors, (2020).

IV. RESULTS AND DISCUSSIONS

IV.1 RESPONDENTS BASIC PERSONAL AND ORGANISATIONAL INFORMATION

Table 1 displayed the respondents' basic personal and organisational information. In terms of organisational ownership, 42.86% of those sampled are from the publicly owned organisations, and 57.14% are from the private sector organisation. This shows that the participant cut across the private and public sector organisations that have something to do with construction works. The states of operation of the organisations of the participants shows that 9.94% are in Akwa Ibom state, Bayelsa state (8.70%), Cross River state (16.77%), Delta state (24.22%), Edo state (18.01%, and Rivers state (22.36%). The participants profession are Architects (30.43%), Builders (13.66%), Engineers (Civil & services) (31.66%), and Quantity

Surveyors (24.22%). This shows that the key professions that form the bulk of the professional employees of construction organisations participated in the study. From their years of experiences in the industry, average years of experience are 13.48 years and this fell within the range 11-15years. This range is still the modal and median class. This period in the construction industry is enough to have gained enough experiences regarding the subject matter of this study. With regards to the educational qualification of the respondents, those with HND are 17.39%, PGD (13.04%), BSc./B.Tech (36.02%), MSc./M.Tech. (29.81%) and those with PhD are (3.73%). This shows that they are academically qualified to contribute meaningfully to the subject of this study. Finally, 91.30% of the respondents are corporate members of their various professional bodies. Only a few of them are still probationer members (8.70%) of their professional bodies. This further shows the quality and expertise possessed by the participants.

Table 1: Respondents Basic personal and Organisational information.

Variables	**Classification**	**Freq.**	**%**
Organizational ownership	Public organisation	69	42.86
	Private organisation	92	57.14
	TOTAL	**161**	**100.00**
States within the zone	Akwa Ibom	16	9.94
	Bayelsa	14	8.70
	Cross River	27	16.77
	Delta	39	24.22
	Edo	29	18.01
	Rivers	36	22.36
	TOTAL	**161**	**100.00**
Profession of construction professionals	Architect	49	30.43
	Builders	22	13.66
	Engineers (Civil & Services)	51	31.68
	Quantity Surveyors	39	24.22
	TOTAL	**161**	**100.00**
Years of experience	5-10years	49	30.43
	11-15 years	57	35.40
	16-20 years	31	19.25
	21-above	24	14.91
	TOTAL	**161**	**100.00**
Educational Qualification	Higher national Diploma (HND)	28	17.39
	Postgraduate Diploma (PGD)	21	13.04
	Bachelor of Science/technology (BSc./B.Tech)	58	36.02
	Master's Degree (MSc./M.Tech.)	48	29.81
	Doctorate degree (PhD)	6	3.73
	TOTAL	**161**	**100.00**
professional affiliation	Member Nigerian Institute of Architect (MNIA)	46	28.57
	Member Nigerian Institute of Builders (MNIOB)	19	11.80
	Member Nigerian Society of Engineers (MNSE)	47	29.19
	Member Nigerian Institute of Quantity Surveyors (MNIQS)	35	21.74
	Probationer	14	8.70
	TOTAL	**161**	**100.00**

Source: Authors, (2020).

IV.2 LEVEL OF AWARENESS OF THE LEAN CONSTRUCTION TECHNIQUES

Figure 2 shows the result of the analysis of the data collected on the level of awareness of the lean construction concept. With 40.99% of them indicating that the level is high, and 28.57% indicating very high, it can be said that the level of awareness of the lean concept within the south-south region of Nigeria, ranges from high to very high. Based on this, the awareness level for lean construction technique is better described as being high. The finding in this section is in line with studies of [13, 3, 12, 11]. The result is, however, not in line with the studies of [7, 33-35]. Notwithstanding that the level of awareness of the lean concept is high; it can further be deduced from Fig. 2 that the Nigerian construction organisations, regulatory agencies and construction professionals are not there yet, as more awareness creation needs to be carried out. The high awareness reported here could be attributed to years of experience of the participants. It is clear that, as one spend more time or age in a system, the more experiences and aware of trends they become.

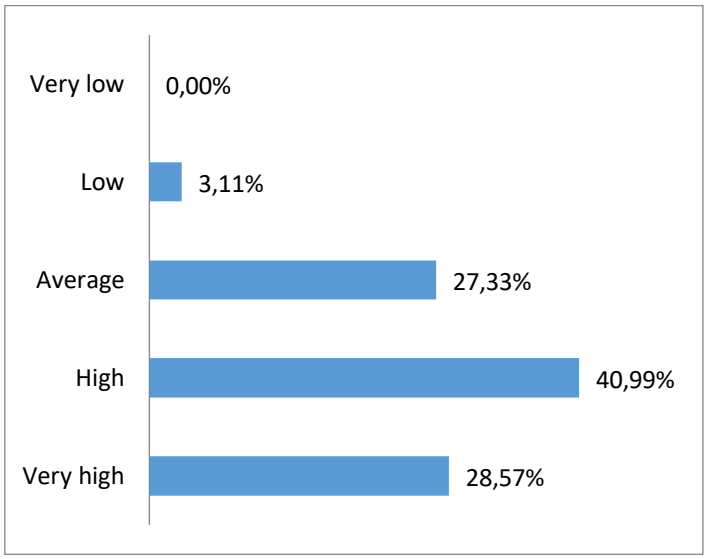

Figure 2: Level of awareness of the lean construction techniques.
Source: Authors, (2020).

IV.3 LEVEL OF ADOPTION OF LEAN CONCEPT ON CONSTRUCTION PROJECTS

On the level of adoption of lean concept on construction projects, the analysis of the participants responses shows that The level range from low (32.92%) to average (35.40%) (see fig 3). Appreciable adoption of the lean concept was however reported (high=23.60% and very high=4.95%). With a total of 71.43% (those who indicated very low to average), it can be said that the adoption level of lean construction on construction projects in Nigeria is low. This is similar to the reports from other climes. [29] and [30] in the UK, reported that there is a low implementation of lean constructions. [32] also reported that the lean concept familiarity and implementation in the Ghanaian construction industry is low. Even in the Moroccan construction industry, the level of implementation of lean construction is low as reported by [11]. [3] also reported a comparatively low level of adoption of lean construction among construction firms in Nigeria. However, in the USA and India, the situation is different as observed from the study of [31]. It was found that the USA and India have recorded successes in reducing waste and making profit from the actual implementation of the lean methods in construction projects. It is vital to stress that reaping of the full benefits of the lean construction principles comes with actual implementation by organisations and other stakeholders.

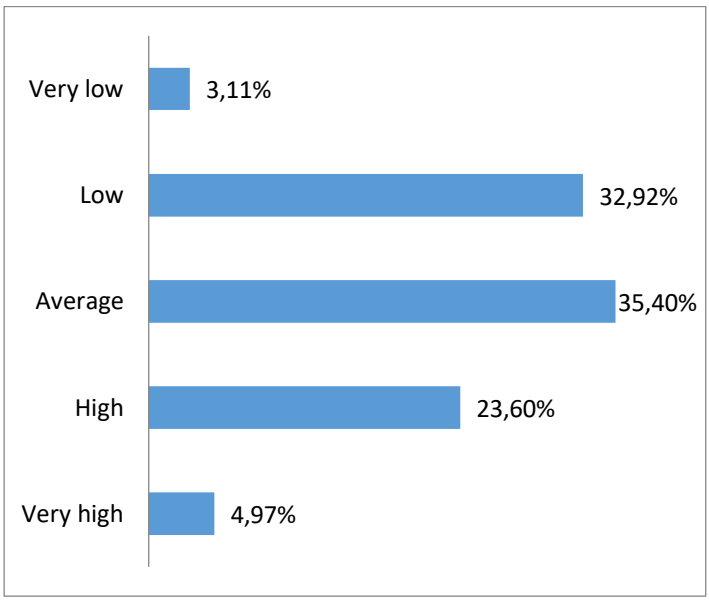

Figure 3: Level of adoption of lean concept on construction projects.
Source: Authors, (2020).

IV.4 AVAILABILITY OF DEDICATED LEAN TEAM/DEPARTMENT

Regarding whether the participants organisation have a dedicated lean team/department, result in Figure 4 shows that the majority of the organisations does not have a dedicated team/department responsible for lean related matters. However, 36% of them indicated that they do engage the services of consultants or advisers for lean related issues. This could be a pointer to why the implementation level is still low despite the high awareness level among organisations and the professionals. The high consultancy fees could also hamper the full-scale implementation of the lean concept in the study area and Nigeria at large. This is because the bulk of construction firms in the area are small and medium-sized.

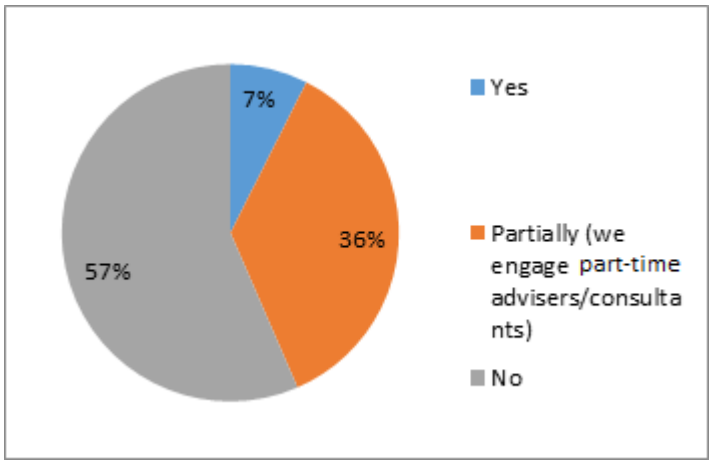

Figure 4: Availability of dedicated lean team/department
Source: Authors, (2020).

IV.5 BENEFITS OF LEAN CONSTRUCTION

There is the possibility of having some sort of difference in the rating style and perception of the assessed variables by the construction professionals from the different states within the study area. Kruskal-Wallis H-Test was conducted to identify the variables in which the views of the participants differ significantly and the proportion of the variables where the rating style is the same and /or differs. As can be seen in column 12 and 13 of Table 2, the pattern of rating on 27 of the variables is the same, and the p-value of these variables is greater than 0.05. These 27 variables represent 84.38% of the assessed variables. Based on the p-value of these variables, it can be said that there is a convergent perception by the professionals regarding them. This further means that there is agreement among the participants that lean construction is a panacea for poor performance of construction projects. The views of the participants was however divergent in 5 of the variables, as their p-value is lower than 0.05 significant level. These variables are; encourage collaboration, design improvement, better and smooth communication among parties, accelerate/improves project activities and delivery method, and greater predictability. These variables represent 15.63% of the assessed variables. These differences in perception maybe attributed to the varying level of understanding and awareness and implementation of the lean concept in the various organisations and projects.

The factor analysis (FA) is preceded by the determination of the factorability and suitability evaluation of the data for FA. From recommendations in extant literature, the sample size of 161 and number of variables of 41 are adequate for factor analysis [65-66]. With an average communalities value of 0.712 for the 41 variables, the sample size becomes meaningless in determining the factorability of variables [67]. Although, there is yet to be an agreement among academics and researchers regarding what should be the ideal number of variable for FA. Also, with the results obtained for the Kaiser– Meyer–Olkin (KMO) and Bartlett test of sphericity, it can be concluded that the gathered data are suitable and factorable. The KMO of 0.759 was obtained and it is higher than the threshold of 0.60 based on [66-69] submissions. Similarly, Bartlett test of sphericity of 0.000, df=820 was obtained, and this shows that it is significant at below 0.05 [66, 70].

Following the suitability and factorability evaluations, the FA executed using principal component analysis (PCA) with varimax rotation, nine factors were suitably retained since their eigenvalues are greater than 1, and they accounted for about 60.41% of the total cumulative variance (TCV). The TCV is higher than the threshold set by [66, 71-72], for adequate construct validity. Furthermore, A strong component structure is present when the factor loading on each component is greater or equal to 0.50 [73]. With this knowing, the rotated component matrix of the benefits of lean construction (Table 2), shows only that variables retained are those with factor loading ranging from 0.50 and above.

Considerations were given to the variable with the higher factor loading (FL) within a component structure, when name a component. In this study, the latent characteristics of other variables within the components where considered in naming components, and this is in addition to the factor with the higher loading other variables are considered. This is because [74] confirmed that the name of components in FA is influenced by the variables under the components.

Table 2: Rotated component matrix of the benefits of lean construction.

	Component									K -W	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**X^2**	**Sig.**
Cost reduction /savings	0.804									2.532	0.623
Improved planning	0.728									6.783	0.079
Improve process control	0.594									6.763	0.08
Minimization of direct costs through effective project delivery management	0.538									7.088	0.136
Labour cost reduction	0.511									2.25	0.745
Value achievement/maximisation		0.8								6.718	0.079
Valuing relationships		0.698								1.833	0.766
Improved life-cycle cost		0.646								6.198	0.182
Encourage collaboration		0.59								12.09	0.007*
Improving the environmental performance			0.83							0.789	0.765
Reduction of the rate of work disruption (reduction of variations)			0.794							7.294	0.063
Risks minimisation and opportunities maximisation			0.679							1.058	0.787
Better quality performances				0.79						5.385	0.146
Design improvement				0.739						12.22	0.011*
Repeat patronage				0.609						4.249	0.236
Increase production efficiency				0.541						5.097	0.165
Improvement in employees motivation					0.773					2.971	0.572
Increased productivity					0.696					7.088	0.135
Better and smooth communication among parties					0.564					24.31	0.000*
Increased in company's revenue and profitability						0.773				3.278	0.351
Better market share						0.715				3.205	0.361
More sales						0.662				0.765	0.858
Maximise the use of multi-skilled workforce						0.501				2.982	0.394
Shorten construction time							0.793			2.248	0.523
Accelerate/ improves project activities and delivery method							0.556			27.51	0.000*
Increases client satisfaction							0.512			0.65	0.885
Waste reduction/elimination								0.728		4.033	0.412
Effective administration of materials on site								0.536		0.73	0.866
Reduction in idle time								0.528		3.723	0.293
Improve the health and safety on site									0.777	5.864	0.118
Reduced rework									0.765	6.503	0.09
Greater predictability									0.504	30.14	0.000*
Eigenvalues	6.09	3.84	3.36	2.64	2.15	1.92	1.73	1.65	1.39		
% of Variance	14.85	9.37	8.2	6.45	5.25	4.68	4.21	4.02	3.39		
Cumulative % of variance	14.85	24.21	32.41	38.86	44.11	48.79	53	57.02	60.41		
number of extracted variables	5	4	3	4	3	4	3	3	3		

Source: Authors, (2020).

*Sig=Pvalue<0.05; K-W= Kruskal-Walis H test.

IV.6 DISCUSSION OF EXTRACTED FACTORS

As can be seen in Table 2 above, the first component has 5 variables loading under it, and accounts for about 14.85% of the total variance explained. Based on the latent characteristics of these variables, this component was named '*cost related benefits'*. The variables are cost reduction/savings, improved planning, improve process control, minimization of direct costs through effective project delivery management, and labour cost reduction.

The second component has 4 variables which are; value achievement/maximisation, valuing relationships, improved life-cycle cost, and encourage collaboration; as the variables that loaded under it, and they accounted for 9.37% of the total variance explain. The component was named '*value and relationship benefits'* based on the features of the variables.

The third component is named '*environmental benefits'* and its account for 8.20% of the total variance explained and with 3 variables loading under it. These variable are; improving the environmental performance, reduction of the rate of work disruption (reduction of variations), and risks minimisation and opportunities maximisation.

The fourth component account for 6.45% of the total variance explained, and has 4 variables loaded under it. These variables are; better quality performances, design improvement,

repeat patronage, and increase production efficiency. A cursory look at these variables shows they are closely link to quality improvement. Based on this, the component was named '*quality improvement benefits*'.

The fifth component is named '*motivation and productivity benefits'.* This component has 3 variables loading under it, in addition to accounting for about 5.25% of the total variance. The variable loading under this component are; improvement in employees motivation, increased productivity, and better and smooth communication among parties.

The sixth component has 4 variables that accounts for 4.68% of the total variance explained. These variables are; increased in company's revenue and profitability, better market share, more sales, and maximise the use of multi-skilled workforce. These variables are closely related to company's profitability and market improvement, thus, this led to the naming of the components as '*profitability and market benefits'*.

The variables that are loaded under the seventh component are; shorten construction time, accelerate/ improves project activities and delivery method, and increases client satisfaction. This component accounts for 4.21% of the total variance explained and based on the characteristics of the variables, it was named '*time and work flow benefits'*.

The eighth component has 3 variables loading under it and accounted for about 4.02% of the total variance explained. The variables that are loaded under these components are; waste reduction/elimination, effective administration of materials on site, and reduction in idle time. A cursory look at these variables shows they are closely related to reduction in waste, and based on this, this component was named '*waste Reduction benefits'.*

The ninth component has 3 variables that loaded under it, and these variables are; improve the health and safety on site, reduced rework, and greater predictability. The component accounts for about 60.41% of the total cumulative per cent of variance. This component was subsequently named '*HS and Rework reduction benefits'*, following the examination of the characteristics of the variables.

The study revealed that the major benefits which made lean construction a panacea for poor construction project performance are; cost related benefits, value and relationship benefits, environmental benefits, quality improvement benefits, motivation and productivity benefits, profitability and market benefits, time and work flow benefits, waste reduction benefits, and HS and rework reduction benefits. The result of this study support findings from previous studies [19, 11, 44, 46, 17, 59]. [11] found that the major benefits of adopting lean construction approach in order of mean weighting are; better project quality, improving safety, improving the environmental performance, reducing overall project duration, and reducing construction cost. [19] found that lean constructions have considerable impact on cost savings, waste minimization, Jobsite safety improvement, reduced energy consumption, and customers' satisfaction improvement. According to [12] and [13], lean construction practice offers a value added technique for designing, managing, construction projects to improve time and workflow performance, efficient resource utilisation, waste elimination, with the overall maximisation of value for money for the clients.

The successful implementation of lean construction on construction projects on building and civil engineering projects, simple and complex projects, have shown impact on cost, time, quality, safety, waste, value addition, client satisfaction, disputes and claim reduction among others. [48] submitted that lean-based construction projects are managed better and easier, have better safety performance records, completed earlier than planned, cost less and have better quality performances. Seven points have been advanced to proof why lean concept must be adopted in construction. These points according to [46], are; continuous improvement in construction industry, focus on smart work through companies management rather than hard work by adopting strategic plans for future, reduces waste production in the field which is useful in increasing the profit, reduces the cost of the project, increase in customer satisfaction, better and smooth communication among parties and increases in productivity.

One of the three groups of benefits of implementing the lean concept identified by [31], is the strategic improvements benefits. Under this group lean techniques showed successes in helping organisations to improve their market share, time delivery of goods and services to customers are reduced, more sales, repeat patronage, increased in company's revenue, profit and cash flows [57]. [17] established that the benefits of lean construction to affordable housing projects are; increase the production efficiency, reducing losses, improved product quality and improving productivity, which produced a direct impact on time reduction, materials and labour savings and profitability.

Construction projects delivery are known to suffer from; time and cost overruns, poor quality, poor health and safety performance, and they have negative effects on the environment due to the volume of waste generated from demolition and rework [41, 20]. These problems lead to loss of profit of the contractors, loss of revenue by the client, abandonment, disputes and claims, amongst other issues. All these problems are overcome when lean construction techniques are implemented. Lean construction is thus, a panacea for the poor construction project performance.

V. CONCLUSION AND RECOMMENDATIONS

This study utilised a well-structured questionnaire distributed by hand and electronically, and the snowball sampling technique to assess the awareness level, adoption level and benefits of lean construction in the south-south region of Nigeria. With the purpose of determining the role of lean concept as a panacea for the poor construction project performance in Nigeria and by extension other developing countries, the data gathered from construction professionals in both the private and public organisations, led to some vital findings.

The study found that construction organisations do not have dedicated team or department for championing the use of lean techniques but engage consultants on part-time basis. Also, the level of awareness of lean construction is high but it s adoption is low. The major benefits which made lean construction a panacea for poor construction project performance are; cost related benefits, value and relationship benefits, environmental benefits, quality improvement benefits, motivation and productivity benefits, profitability and market benefits, time and work flow benefits, waste reduction benefits, and HS and rework reduction benefits. These benefits cover the key areas and issues of project performance determinants in the construction industry of developed and developing countries. Construction project cost, time, and quality are majorly the key indicators for a successful and well performed project. Contractors are responsible for the delivery of the finished project and the capability to meet client needs and expectations will add value to the project. Where this is achieved, there will be little or no disputes and claims. Without disputes and claim, every of the parties are satisfied. Judging from the benefits of lean construction found in this study, lean construction is the solution to: time overrun, cost overrun, lack of

value addition, disputes, landfill, poor quality, higher waste, lack of efficiency, lack of motivation, poor productivity, poor HS performance, rework, lesser market share, and loss of profit and revenue. Thus, lean construction is a panacea for the poor construction project performance.

To further encourage the implementation of lean construction for curing all construction project ills, the following recommendations were made for better project performance;

1. Government legislation on the implementation of lean concept on public projects is required, and this must be backed with adequate monitoring and enforcement.
2. Construction clients should engage lean construction contractors, and project managers should also engage professionals that are knowledgeable about the lean method. This is in a bit to take full advantage of the benefits therein, which cut across all the parties to the contract, the project and the environment.
3. Creation by organisations of special/dedicated department for the implementation of the lean concepts. This will further increase awareness level, improve familiarity and understanding of the concept.
4. In addition to other pre-qualification documents, tenderers should be made to produce evidence of 'lean performance' on previous projects. This will further improve awareness and adoption by contractors. Is it also another smart moves toward ensuring sustainability.

Knowing the benefits of lean construction to the adoption of the lean concept by construction organisations as part of the policies and culture in project delivery. The management of construction organisations will find this study useful in making decision towards uptake of lean method. Key players in the construction industry will adopt the findings of this study in making decisions regarding sustainability. This is because waste minimisation is targeted to environment, health and safety covers the social dimension of sustainability and cost, profit and the market covers the economic dimension. This study also add to the existing body of knowledge on lean construction in Nigeria and globally.

Although, the study showed how beneficial the lean construction techniques can be in areas of achieving sustainable construction and remedying ills of construction project delivery that affect project parties, its geographical boundary and sample size could limit the generalisation of the findings. Based on this, a similar study that will adopt interview in addition to questionnaire could be carried out in other geo-political zones or other developing countries in Africa with similar level of technology/construction methods. This will make data available for comparison. A study that will compare the role of sustainable construction and lean construction in the achievement of sustainability could be embarked upon.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: William Nkeonyeasua Nwaki and Chidiebere Emmanuel Eze.
Methodology: Chidiebere Emmanuel Eze.
Investigation: William Nkeonyeasua Nwaki and Chidiebere Emmanuel Eze.
Discussion of results: Chidiebere Emmanuel Eze.
Writing – Original Draft: William Nkeonyeasua Nwaki and Chidiebere Emmanuel Eze.
Writing – Review and Editing: William Nkeonyeasua Nwaki and Chidiebere Emmanuel Eze.
Resources: William Nkeonyeasua Nwaki and Chidiebere Emmanuel Eze.
Supervision: Chidiebere Emmanuel Eze.
Approval of the final text: William Nkeonyeasua Nwaki and Chidiebere Emmanuel Eze.

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RESEARCH ARTICLE OPEN ACCESS

NATURAL RADIOACTIVITY AND EXTERNAL DOSE RATES IN TAILING SAMPLES FROM ROSTERMAN GOLD MINE, KAKAMEGA COUNTY, KENYA

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ABSTRACT

In this article, documented results of natural radionuclide concentrations in tailings at Rosterman gold mine, Kakamega county, Kenya were evaluated. Thirty tailing samples from Rosterman gold mine were collected as per standard sampling procedures and were analyzed for ^{238}U, ^{232}Th and ^{40}K by NaI (TI) gamma-ray spectroscopy. The activities of ^{238}U, ^{232}Th and ^{40}K was found to vary from 39 ± 1.63 Bq/Kg to 118 ± 4.43 Bq/Kg, 72 ± 2.24 Bq/Kg to 223 ± 8.36 Bq/Kg and 85 ± 3.6 Bq/Kg to 362 ± 10.65 Bq/Kg respectively. Radium equivalent activities were found below 370 Bq/Kg in all the collected samples. External gamma dose rates estimated from the levels of radionuclides in tailings had a range of 32 ± 3.4 nGy/h to 68 ± 5.83 nGy/h. Hence, mining of gold at Rosterman has minimal significant health implications to the general population and the miners.

I. INTRODUCTION

The earth has always been bombarded by high energy particle showers in the lower atmosphere. Additionally, the earth's crust contains radionuclides. For most individuals, exposure to natural background radiation is the most significant part of their total exposure to radiation [1]. Radon is usually the largest natural source of radiation contributing to the exposure of members of the public, sometimes accounting for half the total exposure from all sources [2]. Besides the shielding provided by the earth's magnetic field, life is shielded against cosmic radiations by an air layer of approximately 10,000kg/m2, which is comparable to a 10m thick water layer [1]. As a result, at sea level the cosmic radiation contributes about 10% of the total dose rate from natural radiation to which human beings have always been exposed [3].

Artisan mining is an important economic sector in many developing countries. However, limited resources and training, and the availability of cheap, but potentially hazardous methods of extraction and processing of minerals can cause significant threats to both miners and the local environment [4]. The natural radioactivity and the suspected high dose rates in these mining areas could probably complicate health problems. The relationship between mining and environment is particularly complex and not yet fully understood especially in developing countries [4]. In Kenya, its noted that this complexity is due partly to the levels of research and lack of adequate and analytical capabilities as well as foolproof diagnostic ability for environmentally related health conditions [5]. It is on this ground that this research work was carried out to determine the contributions of tailings from the mining site to the natural radioactivity exposure levels in the area.

II. MATERIALS AND METHODS

II.1 STUDY AREA

The study was carried out at Rosterman which is within Lurambi sub – county, Kakamega Municipality, Kakamega county. Lurambi sub – county is bordered by Navakholo, Malava, Shinyalu, Khwisero, Mumias East, Ikolomani and Butere sub – counties. The study area is shown in Figure 1.

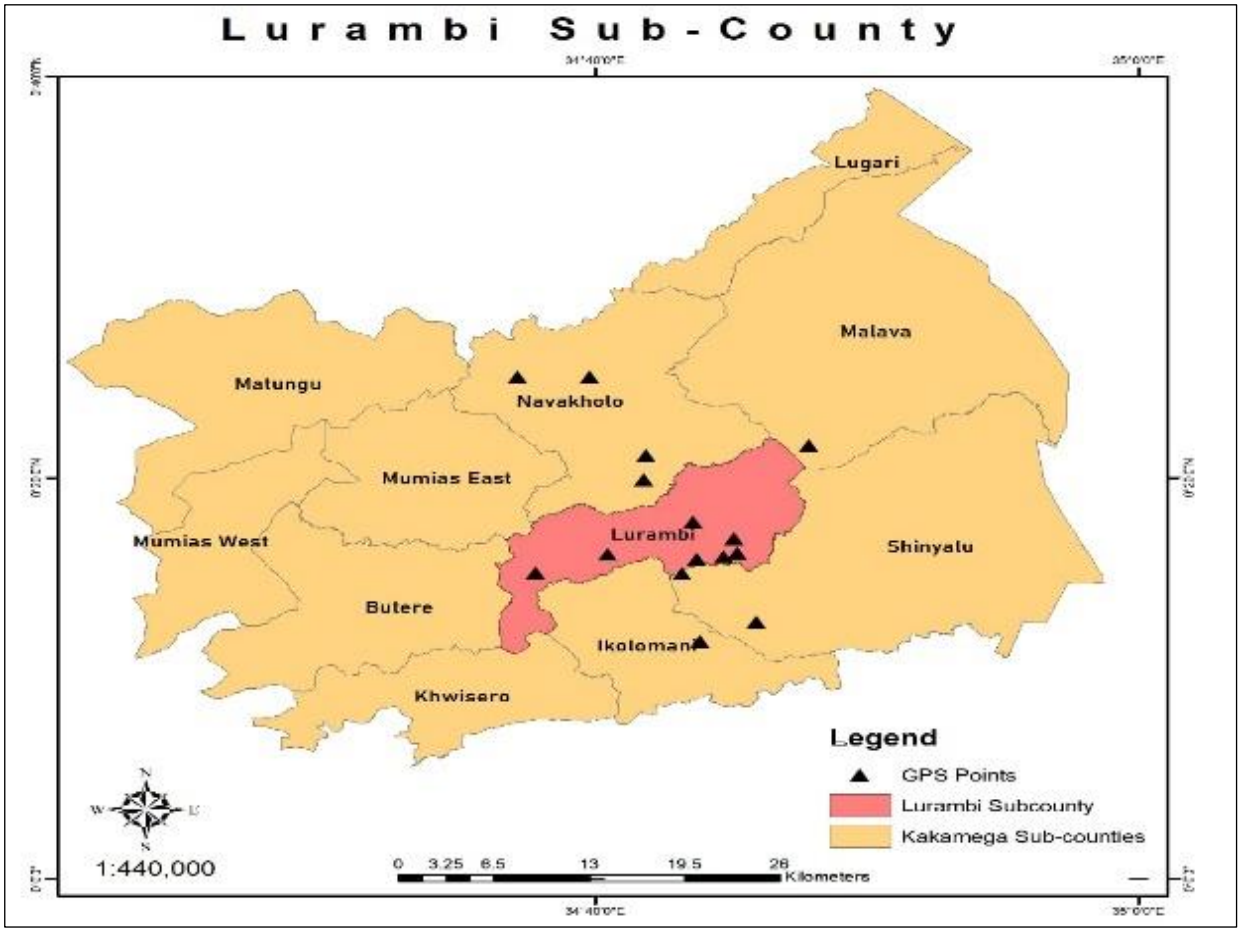

Figure 1: Map of the Lurambi Sub County and its Neighboring Sub Counties.
Source: [6].

Rosterman is globally located at N00°16.964, 34° 45.112'E. Figure 2 shows the sampling points.

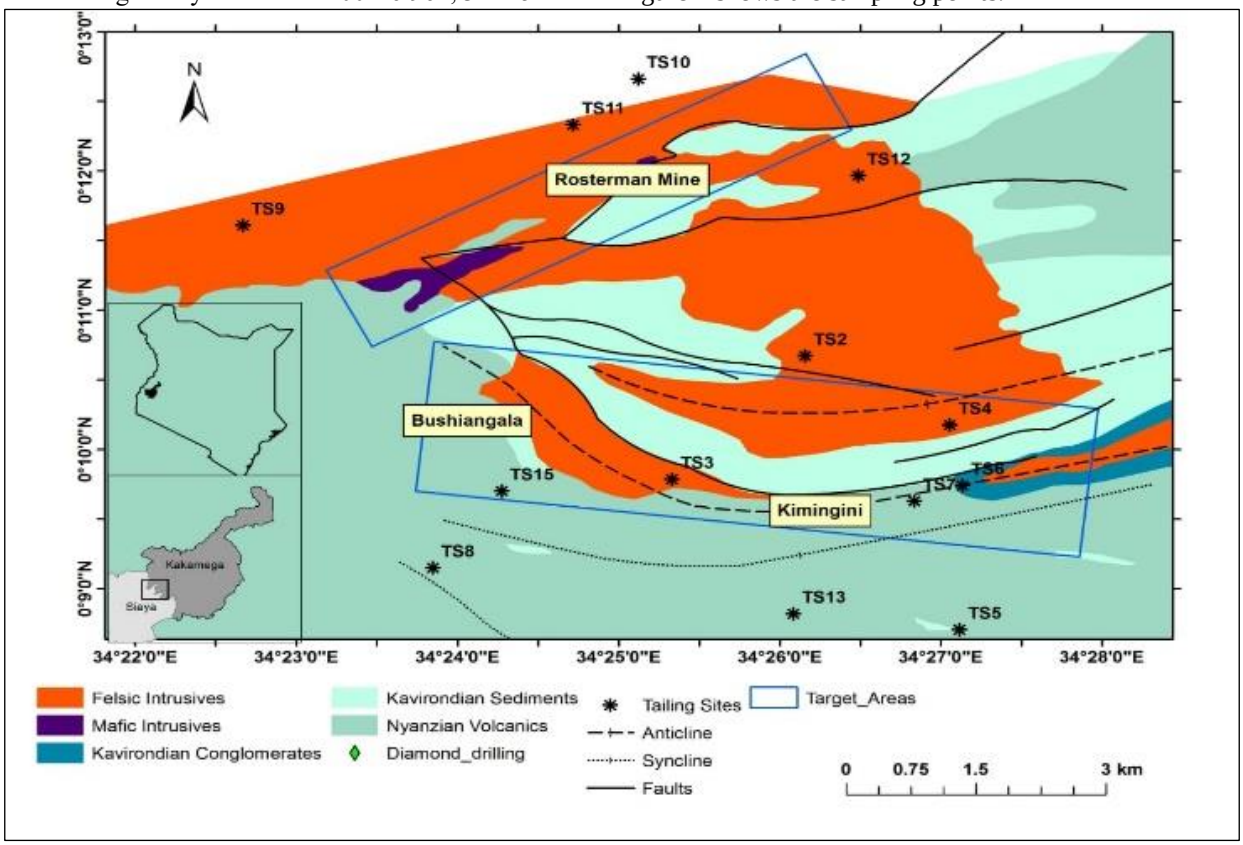

Figure 2: Sampling Points at the Study Area.
Source: [7].

The area of research involves artisanal mining activities that may result in exposure to natural radioactivity levels to the miners and the general public.

II.2 SAMPLE COLLECTION AND PREPARATION

A total of 30 samples were randomly collected within the selected tunnels of the Rosterman gold mine. In the laboratory, each of the tailing samples was dried under sunlight for 5 days and then oven dried at a temperature of 105 °C for about four hours until all moisture content was completely expelled. The dried samples were then grinded into fine powder using a mortar and pestle and then sieved through a 2 mm mesh size [8]. They were then poured into 200g mass plastic containers. The plastic containers were then sealed, weighed and stored for 4 weeks to allow the short-lived daughters of ^{238}U and ^{232}Th decay series to attain secular equilibrium with their long-lived parent radionuclides [8]. The soil samples were each counted using a NaI (TI) gamma ray detector for a period of 36,000 S [9].

II.3 INSTRUMENT CALIBRATION

The tailing samples measurement were made by direct non-destructive instrumental analysis with a computerized gamma spectrometry system made up of NaI(TI) detector. The calibration of NaI(Tl) gamma-ray spectrometer and decomposition of measured spectrum into components were done using three standard materials (RGK-1, RGU-1 and RGTH-1 for potassium, uranium and thorium, respectively) which were obtained from International Atomic Energy Agency [10]. The ^{226}Ra activities for samples assumed to be in radioactive equilibrium were estimated from ^{214}Pb (351.92 keV) and ^{214}Bi (609.31 keV). The gamma-ray energies of ^{212}Bi, ^{212}Pb and ^{228}Ac were used to estimate activity of ^{232}Th. The activity concentrations of ^{40}K were measured directly by its own gamma rays (1460.81 keV).

II.4 SAMPLE ANALYSIS

II.4.1 Activity Concentration of Radionuclides in Bqkg^{-1}

Equation 1 is the analytical equation that was used in the calculation of the radionuclide activity concentrations in Bqkg^{-1} [9].

$$A_c = \frac{N_D}{p.n.m} \quad (1)$$

Where N_D is the net count rate (cps), measured count rate minus background count rate, p is the gamma-ray emission probability, n (E) is the absolute counting efficiency of the detector system, m is the mass of the sample (kg).

II.4.2 Radium Equivalent (Raeq)

Equation 2 shows the analytical equation used for calculating the radium equivalent [8].

$$Ra_{eq} = C_{Ra} + 1.423C_{Th} + 0.077C_K \quad (2)$$

Where C_{Ra}, C_{Th} and C_k are the mean activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in tailing samples respectively expressed in Bqkg^{-1}.

II.4.3 Estimation of Absorbed Dose Rate (D)

The absorbed dose rate was calculated from activity concentration of ^{232}Th, ^{238}U and ^{40}K using the activity concentration-dose (nGy^{-1} per Bq/kg) conversion factors of 0.622, 0.462 and 0.0432 [10]. Equation 3 below shows how to calculate the dose rate given the activity concentrations [11].

$$D(nGyh^1) = 0.427A_U + 0.622A_{Th} + 0.043A_K \quad (3)$$

Where A_U, A_{Th}, and A_K is the average activities concentration of ^{238}U (^{226}Ra), ^{232}Th, and ^{40}K in Bqkg^{-1}, respectively in the mixture of the tailing samples.

II.4.4 Hazard indices

Internal hazard index (H_{in}) measures the internal exposure due to intake of terrestrial radionuclides by inhalation while external hazard index (H_{ex}) measures the external exposure to gamma radiation from the natural radionuclides in the gold mining site. External exposure may occur when the body comes in contact with radiation whose energy is elevated [12]. For radiation to be considered to have negligible hazardous effects to the public, both internal and external hazard indices should be less than 1 unit [13]. The internal hazard index was calculated using Equation 4 while external hazard index was determined using Equation 5 as given below [14].

$$H_{in} = \frac{C_{Ra}}{185} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \quad (4)$$

$$H_{Ex} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \quad (5)$$

Where C_{Ra}, C_{Th}, and C_K represent the mean activity concentrations of radionuclides in Bqkg^{-1}.

III. RESULTS AND DISCUSSIONS

III.1 ACTIVITY CONCENTRATION OF THE RADIONUCLIDES

The specific activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in tailings were evaluated separately using the analytical Equation 1 and the results showing the range and average activity of tailings tabulated in Table 1.

Table 1: Mean and Range of Activity Concentrations of the Radionuclides.

	Activity concentration values		
Radionuclide	^{226}Ra	^{232}Th	^{40}K
Minimum	39 ± 1.63	72 ± 2.24	85 ± 3.6
Maximum	118 ± 4.43	223 ± 8.36	362 ± 10.65
Mean	83 ± 4.67	108 ± 4.75	250 ± 11.24

Source: Authors, (2020).

The mean activity concentration of ^{40}K, ^{232}Th and ^{226}Ra for the tailing samples collected were 250 ± 11.24 Bq/Kg, 108 ± 4.75 Bq/Kg and 83 ± 4.67 Bq/Kg. The average activity concentration of ^{40}K in the collected sediments was below the world's mean of 400 Bq/Kg while that ^{238}U and ^{232}Th were higher than the worlds average of 35 Bqkg^{-1} and 45 Bqkg^{-1} respectively [15]. The high abundance of ^{40}K was as a result of presence of silicate minerals in the sampled tailing [16]. However, the mean values of ^{238}U and

^{232}Th were far below the exemption level of 1000 Bqkg^{-1} for ^{238}U and ^{232}Th [13]. The activity concentration of ^{238}U in the collected tailing samples is shown in Figure 3.

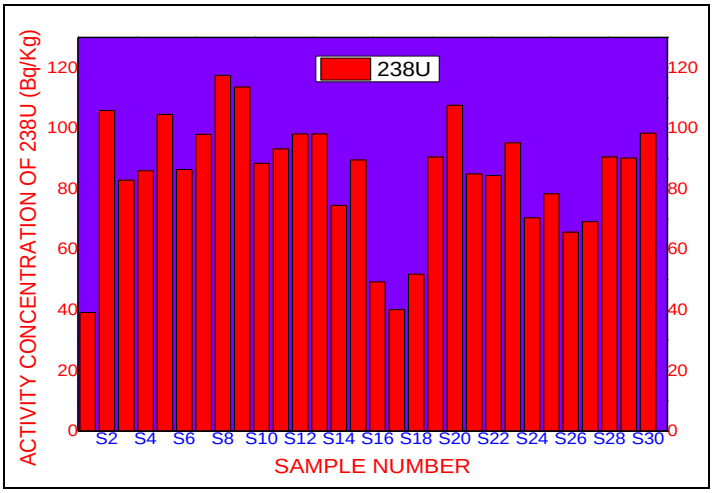

Figure 3: Activity Concentrations of 238U in the Collected Tailing Samples.
Source: Authors, (2020).

The activity concentration of ^{238}U of the collected samples in Bq/Kg ranged from 39 ± 1.63 to116 ± 4.43 (Figure 3). The average activity concentration for the analyzed samples was 83 ± 4.67 Bq/Kg. This is above the recommended value of 35 Bqkg^{-1} [17]. Most of the samples reported an activity concentration above the agreed value but below the recommended exceptional value of 1000 Bq/Kg [18].

III.2 DOSE RATES

Evaluation of absorbed gamma dose rates DR (nGyh^{-1}) in air 1 m above the ground was done by converting specific activity concentration to absorbed dose using the suggested conversion factors of 0.427, 0.662 and 0.043 for ^{226}Ra, ^{232}Th and ^{40}K respectively [19]. To estimate annual individual's total risks as a result of gamma radiation exposure, the absorbed dose was modified to Annual Effective Dose Rates AED (mSvy^{-1}) using guidelines and estimated Kenyan occupancy factors for indoor and outdoor exposures [7]. The average values of absorbed dose rate and annual effective dose rates in all the collected samples were tabulated as shown in Table 2.

Table 2: Radiological Results for the Tailing Samples.

Quantity	Range	Average
Radium Equivalent (Bq/kg)	164 ± 6.92 to 354 ± 16.52	272 ± 12.24
Absorbed dose rate (nGy/h)	32 ± 3.4 to 68 ± 5.83	52.45 ± 5.4
AEDR Outdoor (mSv/y)	0.10 ± 0.00 – 0.40 ± 0.02	0.30 ± 0.01
AEDR Indoor (mSv/y)	0.20 ± 0.01 – 0.50 ± 0.02	0.40 ± 0.02
H_{ex}	0.50 ± 0.02 – 1.0± 0.05	0.90 ± 0.04
H_{in}	0.30 ± 0.02 – 1.10 ± 0.04	0.80 ± 0.03

Source: Authors, (2020).

All the absorbed dose rates were below the recommended criterion value of 60 nGy/h except a few samples. Both the indoor and outdoor annual effective dose rates were below the recommended limit of 1 mSv/y [19]. Hence mining of gold at Rosterman has minimal health implication to the miners and the general population.

III.3 RADIOLOGICAL HAZARD INDICES

The values for radium equivalent, internal and external hazard indices varied for each sample suggesting the non-uniform crustal distribution of natural radionuclides [20]. The average values for radium equivalent, internal and external hazard indices for the tailing samples were presented in Table 2. The mean values for radiological indices such as Radium equivalent was below the Permissible level of 370 Bq/Kg while that of external hazard index was also below the permissible limit of a unit [15]. The internal hazard index for the collected tailing samples is shown in Figure 4.

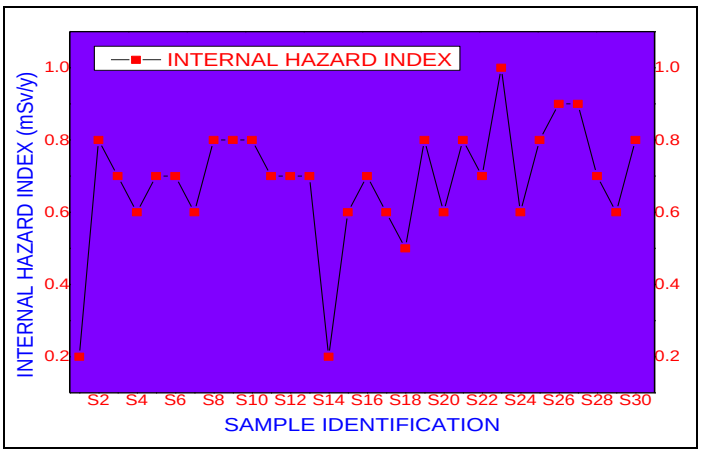

Figure 4: Internal Hazard Index for the Collected Samples.
Source: Authors, (2020).

All the collected samples reported internal hazard index value below the recommended average value of 1 mSv/y (Figure 4). Since the average radium equivalent was below a permissible limit of 370 Bq/Kg [13], while internal hazard index and external hazard index were below a unit, the radiation exposure to the miners and the public due to the tailings from Rosterman gold mine was insignificant.

IV. CONCLUSIONS

The radiological analysis of all the collected tailing samples has been evaluated. Generally, the variation in the activity concentration in the tailing samples was attributed to the differences in the minerals present in the individual sample. The average absorbed dose rate for the tailing samples was lower than the worlds reported mean of 60 nGy/y. Both indoor and outdoor AEDs for the samples analyzed were below permissible dose limit of 1 mSv/y recommended by UNSCEAR and ICRP bodies, respectively. Radium equivalent in the samples were below 370 Bq/kg, the recommended limit for a material to be considered to cause significant health hazards. The possible risks associated with exposure to gamma radiation through inhalation or direct external irradiation was examined by calculating the internal and external radiation hazard indices, which were found to be within the globally acceptable range, hence, gold mining at Rosterman has minimal health threat on the miners and the general public.

V. AUTHOR'S CONTRIBUTION

Introduction: Conrad Khisa Wanyama, John Wanjala Makokha and Michael Nakitare Waswa.
Methodology: Conrad Khisa Wanyama and Fred Wekesa Masinde.
Investigation: Conrad Khisa Wanyama and John Wanjala Makokha.

Discussion of results: Conrad Khisa Wanyama, John Wanjala Makokha and Fred Wekesa Masinde.
Writing – Original Draft: Conrad Khisa Wanyama.
Writing – Review and Editing: Conrad Khisa Wanyama and Fred Wekesa Masinde.
References: Fred Wekesa Masinde, Michael Nakitare Waswa and Conrad Khisa Wanyama.
Supervision: John Wanjala Makokha, Fred Wekesa Masinde and Michael Nakitare Waswa.
Approval of the final text: Conrad Khisa Wanyama, John Wanjala Makokha, Fred Wekesa Masinde and Michael Nakitare Waswa.

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RESEARCH ARTICLE OPEN ACCESS

POTENTIAL OF SEED OIL OF HILDEGARDIA BARTERI (MAST.) KOSTERM FOR BIODIESEL PRODUCTION

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ABSTRACT

This study analysed seed oil of *H. barteri* as a source of biofuel. Mature fruits of *H. barteri* were collected from two mother trees and dehulled, oven and sun-dried and milled. Mechanical extractor and solvent extraction (N-Hexane) was used to obtain oil and analysed for presence of C, H, O, S, N, Pb, Cd, Ni, and Co; physicochemical properties, calorific value. Oil yields ranged from 23.15-30.53% for mechanical and solvent methods. Specific gravity, cloud point, conradson carbon, acid value and iodine values ranged from 0.83-0.85, 7.4-8.3^{0}C, 0.16-0.27%, 31.85-33.95 mgKOH and 57.3-61.8 respectively while C, O, H, N and S contents were generally higher in oil obtained by mechanical extraction. The Pb level was least (0.007%) in solvent extracted oil and highest (0.023%) in sun-dried mechanically extracted oil. Iodine values of solvent and mechanically extracted samples were 61.85 and 58.6 respectively. Calorific value of sun-dried solvent extracted oil was slightly higher (36,140kj/kg) than the oven-dried (35,690kj/kg). Results obtained showed promising indication that the seed oil of *Hildegardia barteri* could be used for production of biodiesel.

I. INTRODUCTION

The use of energy either domestically or industrially has been one of the common things all over the world. The different forms of energy which are categorized as either renewable or non-renewable, all channels down to the production of either primary goods (i.e. processing of raw foods into consumable forms) or/and secondary goods (like production of simple tools, machines) for the survival of man [1].

As energy plays a fundamental role in shaping human condition, it has also been argued that it is the key "to the advance of civilization," and that the evolution of human societies is dependent on the conversion of energy for human use [2]. Based on this fact, the quest for energy for human use is continuous and researches tends towards the production of renewable energy that would bring about improved air quality, lower consumption of fossil fuel and reduce green-house gas emission as reported by CFS (2012) [3]. This therefore informs the identification and production of energy from suitable biomass sources (such a`s animal fat, algae, plant seed oil and crops) that can provide high energy outputs- an alternative to the conventional fossil fuel sources.

II. LITERATURE REVIEW

II.1 BRIEF DESCRIPTION OF PLANT SPECIES

Hildegardia barteri (Mast.) Kosterm tree plant belongs to the family Malvaceae. It is primarily an ornamental tree in West Africa, grown only for its bright beautiful flowers which mature into one-seeded pods during the dry season [4]. Though edible, only few parts of West Africa are observed to consume the kernels either raw or roasted like peanuts [5], or used as condiments in traditional food preparations because of its oil content [6]. This research is however chosen and carried out to maximize the inherent potentials that could be derived from fruits or seeds of lesser used species such as *Hildegardia barteri* in order to avoid wastage of biomass resources. The energy value and other essential parameters that ensure a consistent quality of fuel were determined from the oil extracted from the fruits of *H. barteri.*

III. MATERIALS AND METHODS

Sample preparation: Fruits of Hildegardia barteri were collected from the premises of Department of Agronomy, University of Ibadan, de-hulled, dried using two methods-sun-drying (SD) and oven drying (OD), weighed, milled and packaged in ziplock bags, prepared for the extraction of oil content using soxhlet extraction (SE) with N –hexane solvent and mechanical method (ME). Samples collected were (OD+SE, SD+SE, OD+ME and SD+ME) results of interactions between the two methods of drying and two methods of extractions.

Experimental Design: For objectives of this study, a 2x2 factorial experiments in a completely randomized design was used for the statistical analysis in order to evaluate the significant difference of parameters analyzed among oil samples. Factor A which was at 2 levels represents the drying methods while factor B represents the methods of extraction which is also at 2 levels.

Determination of percentage (%) yield: The percentage yield was calculated using the equation shown below [7]:

$$\%\ Oil\ yield = \frac{Weight\ of\ oil}{Weight\ of\ unextracted\ milled\ seed} \times 100 \quad (1)$$

Elemental Analysis of Seed Oil

Determination of Carbon, Hydrogen, Oxygen and Nitrogen.

The following procedure was used to determine the essential elements except for sulphur.

2g of oil sample was weighed into platinum crucible and placed in a Leibig-pregle chamber containing Magnesium percolate and sodium hydroxide. The sample was burnt off to produce carbondioxide and water. The CO2 was absorbed by Sodium hydroxidewhile the water was absorbed by magnesium percolate. The amount of water and CO2 were calculated by difference.

$$\%\ C \quad \frac{a \times 0.2727}{Weight\ of\ unextracted\ milled\ seed} \times 100 \quad (2)$$

$$\%\ H = \frac{b \times 0.117}{Weight\ of\ unextracted\ milled\ seed} \times 10 \quad (3)$$

$$\%\ O = 100 - (\%C + \%H) \quad (4)$$

Determination of nitrogen

Nitrogen content was determined using kjeldahl method; the formula used for calculating % N was:

$$\%\ \mathrm{N} = \frac{((\mathrm{S} - \mathrm{B}) \times \mathrm{N} \times 0.014 \times \mathrm{D})}{(\text{Weight of milled seed} \times \mathrm{V}) \times 100} \quad (5)$$

Where,
S = Sample titration reading
B = Blank titration reading
N = Normality of HCl
D = Dilution of sample after digestion
V = Volume taken for distillation
0.014 = Milli equivalent weight of Nitrogen

Procedure for determining Sulphur from the digest

5ml of the digest was pipette into a 100ml beaker and 10ml of distilled water was added and mixed thoroughly to a complete homogenized solution. Then 1ml of 1% Barium gelatin solution was added to precipitate the sulphur. Working standard of sulphur was prepared from range 0-50mg/l and treated similarly like sample.

Absorbance of standard as well as sample was read on a spectronic 21D spectrophotometer at a wavelength of 420nm.

Sulphur in mg/100g was calculated using the formula:

$$Sulphur = \text{Absorbance} \times \text{gradient factor} \times \text{dilution factor} \quad (6)$$

Heavy metals Analysis

Heavy metal analysis of the oil was determined according to the methods of ASTM 3174-76 [8] with the use of the atomic absorption spectrophotometer (AAS) to determine elements such as Pb, Cd, Ni and Co. 0.5g of each sample was weighed into a beaker and 10ml of an acid solution (Nitric/perchloric acid) in ratio 1:2 was added to the sample in the beaker. Then it was allowed to undergo heating on a hot plate at 105°C for an hour. The colour change while heating was observed to be from brown to clear colourless. The digest at this point was allowed to cool. The digest was then read on the atomic absorption spectrophotometer to determine the following metals.

Determination of Physicochemical properties

The extracted oil was analyzed for biodiesel physical properties after the procedures of AOCS, (1978) [9] and AOAC, (1984) [10] while the chemical properties were investigated following standard methods such as ASTM (1998) [11] and [10].

Determination of cloud point

A glass bottle containing 50ml of the oil with an inserted thermometer was immersed together in a water bath and used to measure the temperature at which crystallization begins in liquid oil. The temperature at which the thermometer was no longer visible was taken as the cloud point (ASTM D 2500).

Determination of Fire point

A 250ml conical flask containing 50ml of the oil with an inserted thermometer was placed on a heating mantle. Continuous heating was done until the oil was decomposed to point of evolution of the volatiles which proceeds so rapidly that continuous combustion occurred i.e a fire. The temperature at which this occurred was taken as the fire point.

Determination of Flash point

2g of the oil was weighed into a cylindrical metal container attached with a 0-100°C mercury in glass thermometer. The set - up was heated at a controlled rate on a Gerhadt Heating Mantle set at 105°C with a naked flame from a match stick being passed over the surface of the heated oil at regular interval of 5mins. The temperature measured by the thermometer at a point at which a flash appears at any point of the surface is known as flash point.

Determination of Specific gravity

10ml of the oil was weighed into a previously weighed empty Specific Gravity Bottle with weight W1. Weight of oil plus bottle was noted as W2. 10ml equal volume of distilled water was weighed into the same bottle and weight of bottle plus water was also noted as W3. Specific Gravity of the oil is determined by using the formula:

$$SG = \frac{(W\_2 - W\_1)}{(W\_3 - W\_1)} \quad (7)$$

Determination of Viscosity

This was measured using a viscometer and with aid of an attached water bath. Viscosities of the oils with respect to that of water at various temperatures (30, 40, 50, 60, 70 and 80°C) were determined using the equation below:

$$ɳo = \frac{(ɳw\ ρo\hat{}t)}{(ρw\ tw)} \quad (8)$$

Where,
ɳo and ɳw = Coefficients of viscosity of oil and water respectively.
ρo and ρw = Densities of oil and water, respectively
to and tw = Times of flow of oil and water, respectively

Acid value/Free Fatty Acid (FFA)

A mixed neutral solvent containing a mixture of 25ml diethylether with 25ml alcohol and 1ml of phenolphthalein solution (1%) was prepared. The mixed solution was then neutralized with 0.1M NaOH. 1g of the oil will be dissolved in a 250ml conical flask containing 25ml of the mixed neutral solvent. The mixture was heated to boiling point and shakened vigorously. The solution was cooled and then titrated with 0.1M alcoholic caustic potash solution with constant shaking using phenolphthalein as indicator until the pink colour persisted for 15sec [12] and [10]. The acid value was calculated as:

$$\text{Acid value (mgKOH/g)} = \frac{(\text{Titre value of alkali} \times 0.1\text{M alkali} \times 56.1)}{((\text{Wt of sample used})\ (g))} \quad (9)$$

%FFA was calculated by multiplying the acid value with the factor 0.503 i.e %FFA = 0.503 x acid value [13].

Determination of Calorific Value

Gross calorific value of oil was determined using a CAL 2K-ECO bomb calorimeter.

IV. RESULTS AND DISCUSSIONS

Percentage Oil Yield: Result obtained shows the mean value of triplicate analysis of the samples (Table 1).

Table 1: Percentage Oil Yield.

Source of Variation	DF	MEAN	P-Value
OD+SE	2	23.15±1.51[a]	0.0238
SD+SE	2	30.53±3.02[b]	
OD+ME	2	21.96±1.35[a]	
SD+ME	2	19.52±2.10[a]	

Source: Authors, (2020).

*Means ±SE of triplicate values with same alphabets are not significantly different; significant at p-value < 0.05.

The range of percentage oil yield obtained considerably agrees with the findings of Matchet (1963) [14]) on the suitability of oil-bearing seed that yield up to 30% for commercial oil applications.

Elemental Analysis: Result obtained from the analysis of these essential elements C, H, O, N and S, shows that all elements except for carbon and hydrogen content are lower in the oils samples (Table 2). Nitrogen and Carbon contents in mechanically extracted samples were observed to be significantly different from the solvent extracted samples. Hydrogen content in the oil samples ranged between 8.3-9.57±0.01%. No significant difference was observed in the oxygen content between the mechanically extracted and solvent extracted samples. The sulphur content which is of environmental concern, obtained in this study compares favorably with the ASTM standard [15] (0.05 % max) except for the SD+SE sample.

Table 2: Elemental analysis of seed oil.

PARAMETER	SAMPLES	MEAN	P-VALUES
% NITROGEN	OD+ME	0.16±0.03[a]	0.0001
	OD+SE	0.26±0.02[b]	
	SD+ME	0.19±0.01[a]	
	SD+SE	0.27±0.01[b]	
% HYDROGEN	OD+ME	8.49±0.01[b]	0.0001
	OD+SE	9.57±0.01[d]	
	SD+ME	8.3±0.01[a]	
	SD+SE	9.38±0.01[c]	
% OXYGEN	OD+ME	17.99±0.51[ab]	0.0001
	OD+SE	18.57±0.01[b]	
	SD+ME	17.7±0.01[a]	
	SD+SE	18.42±0.01[b]	
% SULPHUR	OD+ME	0.02±0.01[a]	0.0227
	OD+SE	0.035±0.01[a]	
	SD+ME	0.035±0.02[a]	
	SD+SE	0.065±0.02[a]	
% CARBON	OD+ME	71.29±0.01[a]	0.0001
	OD+SE	72.05±0.01[b]	
	SD+ME	71.33±0.02[a]	
	SD+SE	72.12±0.01[b]	

Source: Authors, (2020).

Means ±SE of duplicate values with same alphabets are not significantly different; significant at p-value < 0.05.

Heavy metals Analysis: Result obtained from this analysis (Table 3) shows that concentration of these heavy metals fall within the permitted range. Proportions of these heavy metals are in line with the maximum concentration permitted by USEPA, standard [16]. The lower values of heavy metals obtained in the oil sample, give basis for the exploitation of oil from *H. barteri* seed as a potential source for clean renewable biodiesel.

Table 3: Heavy metal Analysis.

		MEAN	P-VALUES		
PARAMETER	**SAMPLES**			**PARAMETER**	**FACTOR B**
Pb	OD+ME	0.017±0.002b,c	0.0003	Pb	OD+ME
	OD+SE	0.01±0.002 a,d			OD+SE
	SD+ME	0.023±0.002e			SD+ME
	SD+SE	0.007±0.001a			SD+SE
Cd	OD+ME	0.0035±0.001b	0.0174	Cd	OD+ME
	OD+SE	0.007±0.001c			OD+SE
	SD+ME	0.003±0.001b			SD+ME
	SD+SE	0.0045±0.001b			SD+SE
Ni	OD+ME	0.025±0.001a,b	0.0004	Ni	OD+ME
	OD+SE	0.029±0.001a			OD+SE
	SD+ME	0.022±0.001b			SD+ME
	SD+SE	0.034±0.002c			SD+SE
Co	OD+ME	0.012±0.001a,b		Co	OD+ME
	OD+SE	0.014±0.001b,c	0.0001		OD+SE
	SD+ME	0.01±0.001a			SD+ME
	SD+SE	0.017±0.002c			SD+SE

Source: Authors, (2020).

Means ±SE of duplicate values with same alphabets are not significantly different; significant at p-value < 0.05.

Physico-Chemical Analysis

Specific gravity (SG): Result revealed no significant difference among the SG of oil samples which ranged between 0.73±0.09-0.91±0.06. This, however falls within fuel range (0.82-1.08) given by CSG [17] and also meets the ASTM [15] (0.87-0.90) standard for biodiesel production.

Fire point: Result revealed significant difference between the mechanically extracted oil and solvent extracted oil samples. Fire point for all samples ranged between 77.3±1.1-85.55 ±0.05 ºC and was observed to be lower than the required ASTM standard.

Viscosity: No significant difference was obtained among the viscosities of the samples. Result ranged between 4.05 ±0.55-4.45 ±0.15mm^2/sec, however, all samples fall within the standard range 2.5-6.0mm^2/sec given by ASTM/EN/IS 15607. This implies that the oil will have good fuel atomization and complete combustion and little or no carbon deposition.

Cloud point: The result obtained shows no significant difference among the oil samples. The cloud point obtained (7.25-8.35 ºC) fall within range (-3 to 12ºC) given by ASTM D6751. Oil samples of *H. barteri* gives good indication of a cold weather biodiesel feedstock.

Conradson carbon (CC): Values obtained shows that all samples have higher value of CC when compared to the maximum unit required by ASTM (0.05%). However, the result falls (0.15-0.28%) within same range with that of jathropha and rubber seed oil (0. 25%) and palm kernel oil (0.35%) (Oghenejoboh and Umukoro, 2014[18]).

Acid value (AV)/ Free-fatty acid (FFA): Result shows no significant difference among the AV and FFA values of the oil samples. Values obtained for all oil samples, was observed to be lower to the maximum value (0.50mgKOH/g) required by ASTM D6751 biodiesel standard. Low acid value is said to be an indicator for edibility of oil as well as their suitability for industrial use but a high acid value is only preferred in biofuels. Therefore, the AV result of the subject species proves its edibility as well as its possible use for green-fuel production.

Iodine value (IV): Result obtained which ranged between 57.95-61.85, was observed to be lower than the standard IV of 120 for biodiesel given by Europe's EN 14214 as cited by [19]. But according to B100Research, most oils and fats have an iodine value of between 44 and 75. Lower iodine value indicates that oil samples have lower degree of unsaturation and higher cloud point but good oxidative stability [20].

Calorific Value (CV): The range of CV obtained among the oil samples was 33.21-36.14MJ/kg. Though, values were observed to be lower when compared to the values obtained in some oil-bearing species such as corn oil and cottonseed oil (39.5MJ/kg), rapeseed oil (39.7MJ/kg), rubber seed oil (37.5 MJ/kg), soyabean oil and sunflower oil (39.6MJ/kg), crambe oil (40.5MJ/kg) and the petroleum diesel (43.8MJ/kg) [21] and [22]; jathropha seed oil (37.761MJ/kg) [18]. However, the result was found to be higher than the CV obtained in the studies of some biomass residues (14.43-16.20 kj/g or MJ/kg) [23]. The calorific or heating value obtained in this study indicates good combustion quality.

Table 4: Comparison of Physico-chemical properties with Biodiesel standard.

Properties	**Biodiesel Standard**	**Result for *H.barteri* oil**
Specific gravity	ASTM D6751 (0.880); ASTM 6751-02 (0.87-0.90)	0.73-0.91
Fire point	Not specified	77.30-84.55 ºC
Flash point	ASTM D6751 (93ºC)	44.35-45.95 ºC
Viscosity	ASTM/EN/IS15607-(2.5-6.0mm^2/sec)	4.05-4.45mm^2/sec
Cloud point	ASTM D6751-(-3 to 12ºC)	7.25-8.35 ºC
Conradson carbon	ASTM D6751 (0.05% max).	0.15-0.28%
Acid value	ASTM D6751 (0.50mgKOH/g)	0.032-0.034 mgKOH/g
Iodine value	EN14214 (120)	57.95-61.85
Calorific value		33.21-36.14MJ/kg

Source: Authors, (2020).

V. CONCLUSIONS

The study on the use of *H. barteri* fruit as a potential source of green-fuel or biodiesel meets almost all requirements for biodiesel production and the following conclusions could be drawn:

The solvent extraction method yielded more oil than the mechanical extraction method. From the elemental analysis, all elements except for carbon and hydrogen content are lower in the

oils samples while the sulphur content and the lower values of heavy metals obtained in this study compares favorably with the ASTM D6751 standard to an extent. The values obtained for specific gravity, viscosity, iodine value, cloud point conradson carbon residue from the physicochemical analysis indicate a good promising quality of biodiesel that will be produced from the oil of *H. barteri* fruit. The calorific values obtained in the oil samples with the highest as 36.14 MJ/kg indicate good combustion quality. Thus, the yield and physicochemical properties attest that *H. barteri* is an oil-bearing tree species suitable for both domestic and industrial applications. Hence, gives a basis for the exploitation of oil as a potential source for clean renewable biodiesel.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Adenike Evelyn Adeniyi and Abiodun Oluwafemi Oluwadare.
Methodology: Adenike Evelyn Adeniyi and Abiodun Oluwafemi Oluwadare.
Investigation: Adenike Evelyn Adeniyi.
Discussion of results: Adenike Evelyn Adeniyi.
Writing – Original Draft: Adenike Evelyn Adeniyi.
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Approval of the final text: Adenike Evelyn Adeniyi and Abiodun Oluwafemi Oluwadare.

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RESEARCH ARTICLE OPEN ACCESS

NON-IDEAL FLOW MODEL FOR A TUBULAR REACTOR AND A STIRRED TANK REACTOR IN-SERIES, USING STIMULUS-RESPONSE TECHNIQUES

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ABSTRACT

This work presents an experimental study on a laboratory scale about the hydrodynamic behavior of fluid flow in a tubular reactor and a stirred tank reactor in-series and varying their arrangement. The experiments were carried out using stimulus-response techniques with a tracer solution of sodium chloride in unit pulse form. The experimental results allowed obtaining the Residence Time Distribution curves R_θ vs θ for different reactor arrangements. The results obtained are similar to those reported by Levenspiel for a battery in-series with a plug flow reactor and a perfectly stirred reactor. The difference found with the studied system is that these show dead water in both equipment. The arrangement of the reactors does not modify the graph of Residence Times Distribution obtained, similar to the ideal situation presented in the literature consulted. As a result of the experimental study and the adjustment of the data, a non-ideal flow model was obtained for different kinds of reactors with dead water, connected in-series and with different arrangements. The simulation of the system for different degrees of back mixing in the system reflects a behavior similar to that of series of reactors of this type, but with ideal behavior.

I. INTRODUCTION

An important role in the analysis of any studied process is the obtention and application of models that, from the mathematical point of view, describe the physical and chemical phenomena present in the system. Many models have been used to characterize the dispersion of fluids in flow systems. The most widely used methods of handling mixing have been based on models using diffusion equations with modified diffusion coefficients. These are called dispersion models and the coefficients are called dispersion coefficients. Some explain the transverse, longitudinal dispersion or both [1-2].

The processes simulation with the help of mathematical models constitutes a scientific method of vital importance for the development of the Chemical Industry [3-10]. Within this branch, chemical reactors occupy a preponderant place, since their particular characteristics (shape, size, etc.) are related to the results of the different chemical reactions that occur within them [11-12].

This work focused on the laboratory-scale assembly of a stirred tank reactor system (RTA) and a tubular one (RT) with the aim of studying, using stimulus-response techniques, the hydrodynamic behavior in them, both individually and in-series combinations. The mathematical model that describes the hydrodynamic behavior of the indicated equipment and its series batteries, arranged in different ways, was another of the objectives of this work.

II. MATERIALS AND METHODS

II.1 STIMULUS-RESPONSE TECHNIQUES

The use of stimulus-response techniques for obtaining flow models has great application in the Chemical Industry [13-16]. With the help of these techniques, studies are carried out on the flow of fluids in various chemical equipment, allowing a better understanding about the characteristics of the equipment and therefore an optimal use of its technological possibilities.

II.2 EXPERIMENTAL SETUP

The system used was set up on a laboratory scale. For this, a glass tubular reactor 81 cm long, 1.6 cm internal diameter and a volume of 162.7 cm^3 was used; in addition, a mechanically stirred tank reactor 13.7 cm high, 10 cm internal diameter and an operating capacity of 827.2 cm^3. The inlet flow to the reactors was set with an OMEGA® model FL50001A flowmeter.

The study of the behavior of the fluid as it passes through the system was carried out using stimulus-response techniques, using 30% (w/v) NaCl as a tracer. The fluid used was water and the dose or injection portion of the tracer was 5 cm^3 as a unit impulse, measuring the concentration of the tracer over time at the end of the reactor system, for which an AZ® model AZ8306 conductivity meter was used. In this way, the solution conductivity values were obtained as it passed through the cell over time (the tracer concentration and the fluid conductivity are directly and linearly related).

The first experimental setup was carried out in such a way that the fluid that passes through the rotameter (A), enters the stirred tank reactor (B) and subsequently passes into the tubular reactor (C) where the conductivity meter (D) measures the concentration of the tracer (Figure 1).

Subsequently, the position of the reactors was inverted, that is, the fluid was first passed through the RT and then through the RTA. Also, experiments were performed on the RT and RTA individually.

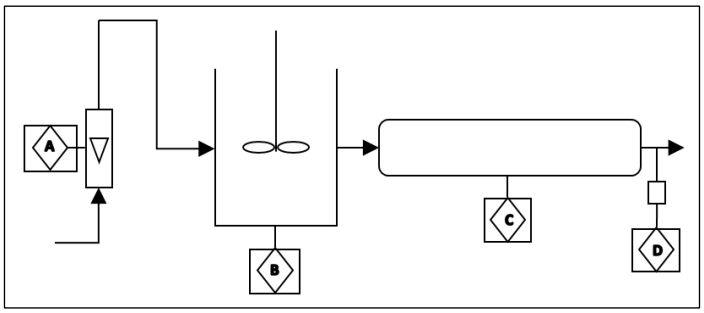

Figure 1: Laboratory-scale assembly of the stirred tank and tubular reactor system connected in series for stimulus-response studies with a 30% NaCl tracer.
Source: Authors, (2020).

We worked with a constant volumetric flow of 6.7 mL/s and in the case of the RTA it was operated with a stirring speed of 1050 rpm.

The conductivity values over time for each combination were tabulated in Microsoft Excel, then the calculations were performed according to the equations reported in the consulted literature[13] that allow us to obtain the values of C_θ vs θ (Residence Times Distribution or RTD).

II.3 DEAD WATER FRACTION CALCULATION

The dead water fraction (f_{Vdi}) in each experiment was found from the RTDs obtained in each experimental system. This fraction is proportional to the quotient between the total unit area (A_{Total}) and the area under the curve (A_i), for values of $\theta > 2$. These calculations were performed for each reactor separately and for their series arrangements. Thus:

$$f_{V_{d1}} = \frac{V_{d1}}{V_{RT}} \propto \frac{A_{RT|\theta>2}}{A_{Total}} \quad (1)$$

$$f_{V_{d2}} = \frac{V_{d2}}{V_{RTA}} \propto \frac{A_{RTA|\theta>2}}{A_{Total}} \quad (2)$$

$$f_{V_{d(1-2)}} = \frac{V_{d1} + V_{d2}}{V_{(RT+RTA)}} \propto \frac{A_{RT-RTA|\theta>2}}{A_{Total}} \quad (3)$$

$$f_{V_{d(2-1)}} = \frac{V_{d2} + V_{d1}}{V_{(RTA+RT)}} \propto \frac{A_{RTA-RT|\theta>2}}{A_{Total}} \quad (4)$$

V_{d1} and V_{d2} are the dead water volumes in the RT and RTA, respectively; $V_{RT}=V_p+V_{d1}$ and $V_{RTA}=V_m+V_{d1}$; V_p and V_m are the volumes of a plug flow reactor and perfect mixing reactor. A_{RT} and A_{RTA} are the areas under the curve obtained from the RT and RTA system, respectively, and their serial arrangements.

II.4 MATLAB® SIMULATION

With the mathematical model obtained, which describes the experimental RTDs, simulations were performed in MATLAB® to validate the effectiveness of the model based on the dispersion number.

A stand-alone MATLAB® version 7.1.0.246 (R14) application was used. This application is suitable for computers running Microsoft® Windows XP, and is for non-commercial research purposes only.

III. RESULTS AND DISCUSSIONS

III.1 FLOW DEFECTS

A preliminary analysis of the experimental curves showed the existence of dead water in the studied systems (**Erro! Fonte de referência não encontrada. - Erro! Fonte de referência não encontrada.**). All curves show an asymptotic behavior to the horizontal axis for values of $\theta > 2$, observing that in the stirred tank reactor this phenomenon is more pronounced. No other flow defects were observed.

III.2 MATHEMATICAL TREATMENT OF DATA

The C_θ values were normalized for subsequent analysis, being $R_\theta=C_\theta/C_{\theta máx}$ then plotting R_θ *vs* θ, which allowed obtaining the residence time curves, fitted to a following mathematical model type:

$$R_\theta = a(\theta - d)^b e^{c(\theta-d)} \quad (5)$$

Then the physical sense of the equation constants (5) was analyzed. According to Levenspiel [13] for discrete values the mean distribution time is given by:

$$\bar{t} \cong \frac{\sum t_i C_i \Delta t_i}{\sum C_i \Delta t_i} \quad (6)$$

And its variance or «*(how long)^2 does the curve take to pass through the measurement point*», is defined as:

$$\sigma^2 = \frac{\sum t_i^2 C_i \Delta t_i}{\sum C_i \Delta t_i} - \bar{t}^2 \quad (7)$$

Thus, defining the dimensionless variance:

$$\sigma_\theta{}^2 = \frac{\sigma^2}{\bar{t}^2} \tag{8}$$

Therefore, the constants of the proposed model (5) can be related according to the dispersion number (D/uL) [1, 2, 17].

The boundary conditions under which the system was treated respond to the «open-open» scenario where the flow is not disturbed as it passes its limits [14]: tracer injection and conductivity meter cell, respectively. For these operating conditions, the dispersion number can be calculated from the following equation:

$$\sigma_\theta{}^2 = 2\left(\frac{D}{uL}\right) + 8\left(\frac{D}{uL}\right)^2 \tag{9}$$

With the values obtained from equation (9) for each test carried out, the model constants were defined as a function of the dispersion number, so:

$$a = \frac{1}{3.7702\left(\frac{D}{uL}\right)^{1.5304}} \tag{10}$$

$$b = 2.6429e^{-8.293\left(\frac{D}{uL}\right)} \tag{11}$$

$$c = \frac{1}{\frac{2}{3}\sqrt{\sigma_\theta{}^2}} \tag{12}$$

$$d = \theta_0|_{C_\theta \neq 0} \tag{13}$$

Finally, substituting the constants in equation (5), the non-ideal flow model was obtained:

$$R_\theta = \frac{(\theta - d)^{2.6429e^{-8.293\left(\frac{D}{uL}\right)}}}{3.7702\left(\frac{D}{uL}\right)^{1.5304}} e^{\left[-\frac{(\theta-d)}{\frac{2}{3}\sqrt{\sigma_\theta{}^2}}\right]} \tag{14}$$

III.3 MATHEMATIC MODEL ANALYSIS

The mathematical model obtained (5), to which all the RTD curves of the experiments carried out fit, both individual (**Erro! Fonte de referência não encontrada.** and **Erro! Fonte de referência não encontrada.**), as their possible combinations RT-RTA and RTA-RT (**Erro! Fonte de referência não encontrada.**), is unique.

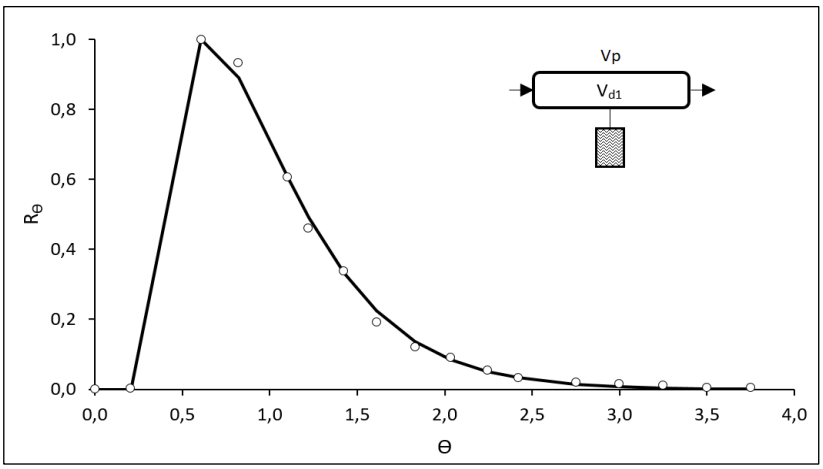

Figure 2: RTD curve for the tubular reactor with R^2 = 0.99, being (o) the experimental data and (-) the proposed model.
Source: Authors, (2020).

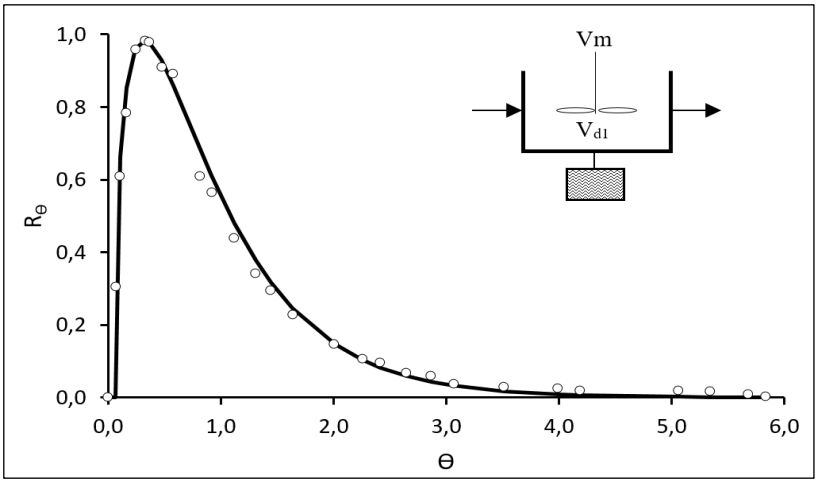

Figure 3: RTD curve for the stirred tank reactor with R^2 = 0.96, being (o) the experimental data and (-) the proposed model.
Source: Authors, (2020).

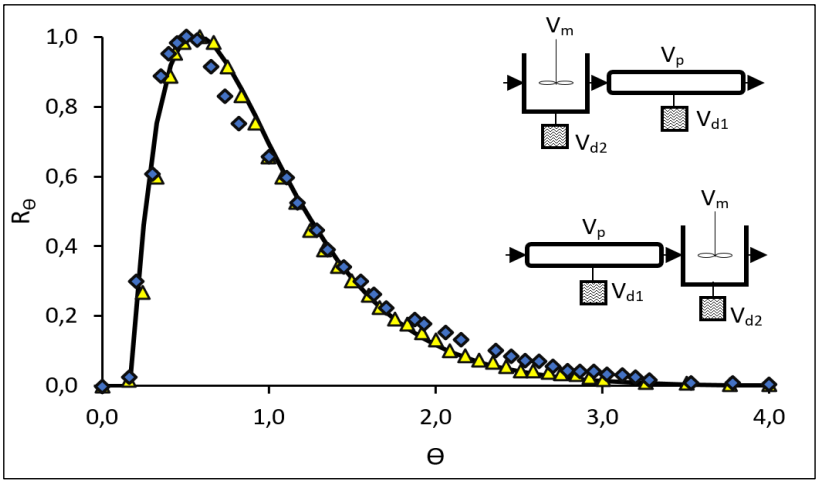

Figure 4: RTD curve for the RTA - RT and RT - RTA dispositions respectively, with $R^2 = 0.98$, being (Δ), (◊) the experimental data of the dispositions tested respectively, and (-) the proposed model.
Source: Authors, (2020).

This non-ideal flow model fits more than 96% regression coefficient in all cases, thus demonstrating the reliability of the results. The experiments carried out in the RT and RTA reactors individually and in their possible series arrangements demonstrate that the model is applicable, novel and useful for the studied non-ideal flow condition.

Unlike the models for ideal systems studied by Levenspiel [13] (**Erro! Fonte de referência não encontrada.**), the non-ideal flow model developed in this work, satisfactorily represents the deviations from the ideal flow characterized by the presence of dead water in the reactors.

III.4 MATLAB® SIMULATIONS OF THE PROPOSED MODEL

Simulations performed in MATLAB® demonstrate the effectiveness of the model based on the dispersion number for «open systems», both for the experiences carried out and for the extreme conditions where the tracer could behave as plug flow when D/uL→0 or complete mixing when D/uL→∞ (**Erro! Fonte de referência não encontrada.**).

The RTD curves shown in **Erro! Fonte de referência não encontrada.** are extrapolated and comparable (showing the same trend) with those reported by Levenspiel [14] (**Erro! Fonte de referência não encontrada.**).

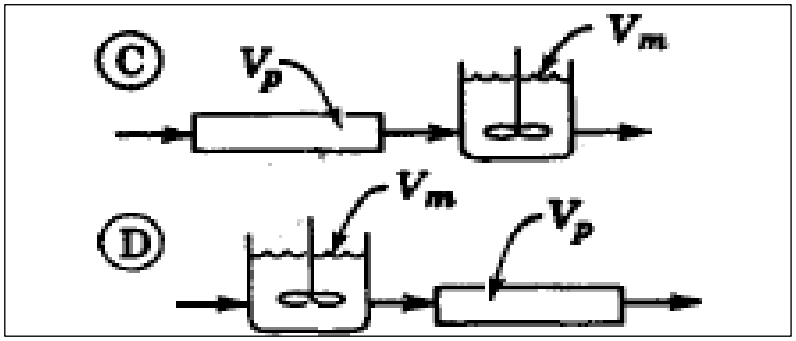

Figure 5: Ideal flow model proposed by Levenspiel.
Source: [13].

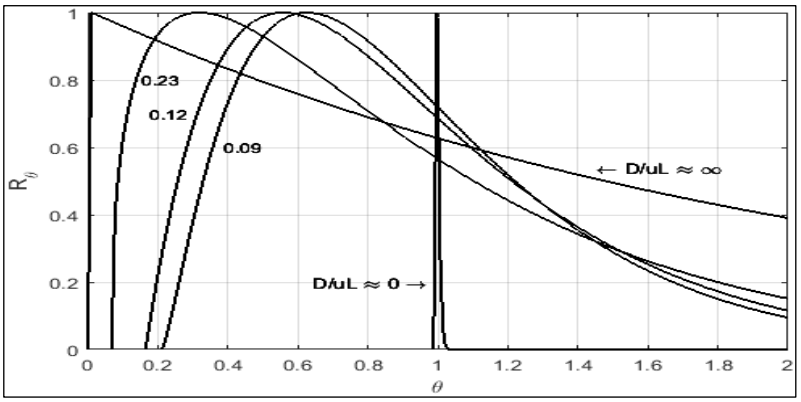

Figure 6: Simulations performed in MATLAB® of the RΘ vs Θ Curve for open systems with different back mix intensities (D/uL) predicted by the proposed model.
Source: [14].

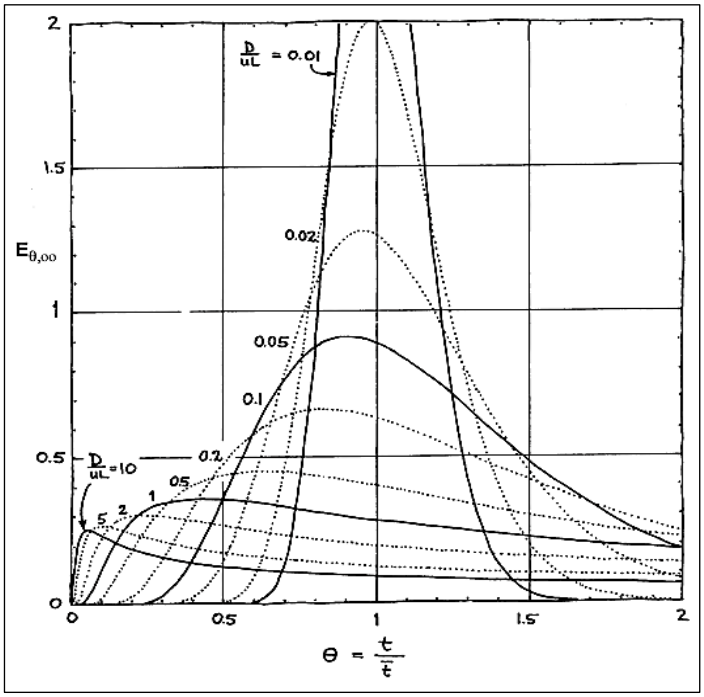

Figure 7: Dimensionless response for open-open boundary conditions as reported by Levenspiel.
Source: [14].

III.5 DEAD WATER FRACTIONS ANALYSIS

Table 1 shows the dead water fractions obtained for the RT, RTA systems and their serial arrangements; as well as those predicted according to the developed mathematical model. Furthermore, the error between the experimental and theoretical data is reported.

As can be seen, the order in which the reactors were combined does not exert a marked influence on the total fraction of stagnant regions, since for the two arrangements studied this value remains practically constant.

Table 1: Dead water fraction for the studied cases: RTA, RT and their serial arrangements.

	Dead water fraction (f_{va})			
	RTA	**RT**	**RTA-RT**	**RT-RTA**
System	0.1646	0.0507	0.0671	0.0699
Model	0.1265	0.0422	0.0551	0.0551
Error	0.0381	0.0085	0.0120	0.0148

Source: Authors, (2020).

This result is characterized by very similar Residence Time Distributions as observed in Fig. 4. As expected, the volumes of dead water in the stirred tank reactor are greater than in the tubular reactor, conditioned by the above characteristics geometric and flow of reactors. The developed mathematical model predicts dead water values well in all cases, with small estimation errors.

IV. CONCLUSIONS

As a result of the experiments to characterize the behavior of the flow through a stirred tank reactor and a tubular reactor and their series combinations, it is concluded that the order in which the tubular reactor and the stirred tank reactor are connected does not influence the flow model of the system, this being the same for the two combinations studied.

Unlike the ideal system reported in the literature, in the studied system there are dead water regions in both reactors and it is concluded that the residence time distribution curves are coincident for the possible series dispositions, as in the case of reactors with ideal behavior. The obtained mathematical model presents a good fit to the experimental data and describes the RTD curves for the systems studied with dead water. It was shown that for the combination of a series RT and RTA, the model that describes its behavior corresponds to a series with dead water in both equipment and that, although the arrangement changes, the RTDs are the same. The sum of the dead water fractions from the series of a tubular reactor and a stirred tank reactor are practically independent from the equipment arrangement. The simulation of the system using the model obtained and the MATLAB® software allowed analyzing the variations that occur in RTDs when the degree of backmix changes in the studied system. A similar behavior to that reported for open-open systems was found.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Iván Leandro Rodríguez Rico and Roberto Jesús Cabrera Carrazana.
Methodology: Iván Leandro Rodríguez Rico and Roberto Jesús Cabrera Carrazana.
Investigation: Iván Leandro Rodríguez Rico, Roberto Jesús Cabrera Carrazana and Yeslié González Bermúdez.
Discussion of results: Iván Leandro Rodríguez Rico and Roberto Jesús Cabrera Carrazana.
Writing – Original Draft: Iván Leandro Rodríguez Rico.
Writing – Review and Editing: Iván Leandro Rodríguez Rico and Roberto Jesús Cabrera Carrazana.
Resources: Roberto Jesús Cabrera Carrazana.
Supervision: Roberto Jesús Cabrera Carrazana and Yeslié González Bermúdez.
Approval of the final text: Iván Leandro Rodríguez Rico, Roberto Jesús Cabrera Carrazana and Yeslié González Bermúdez.

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