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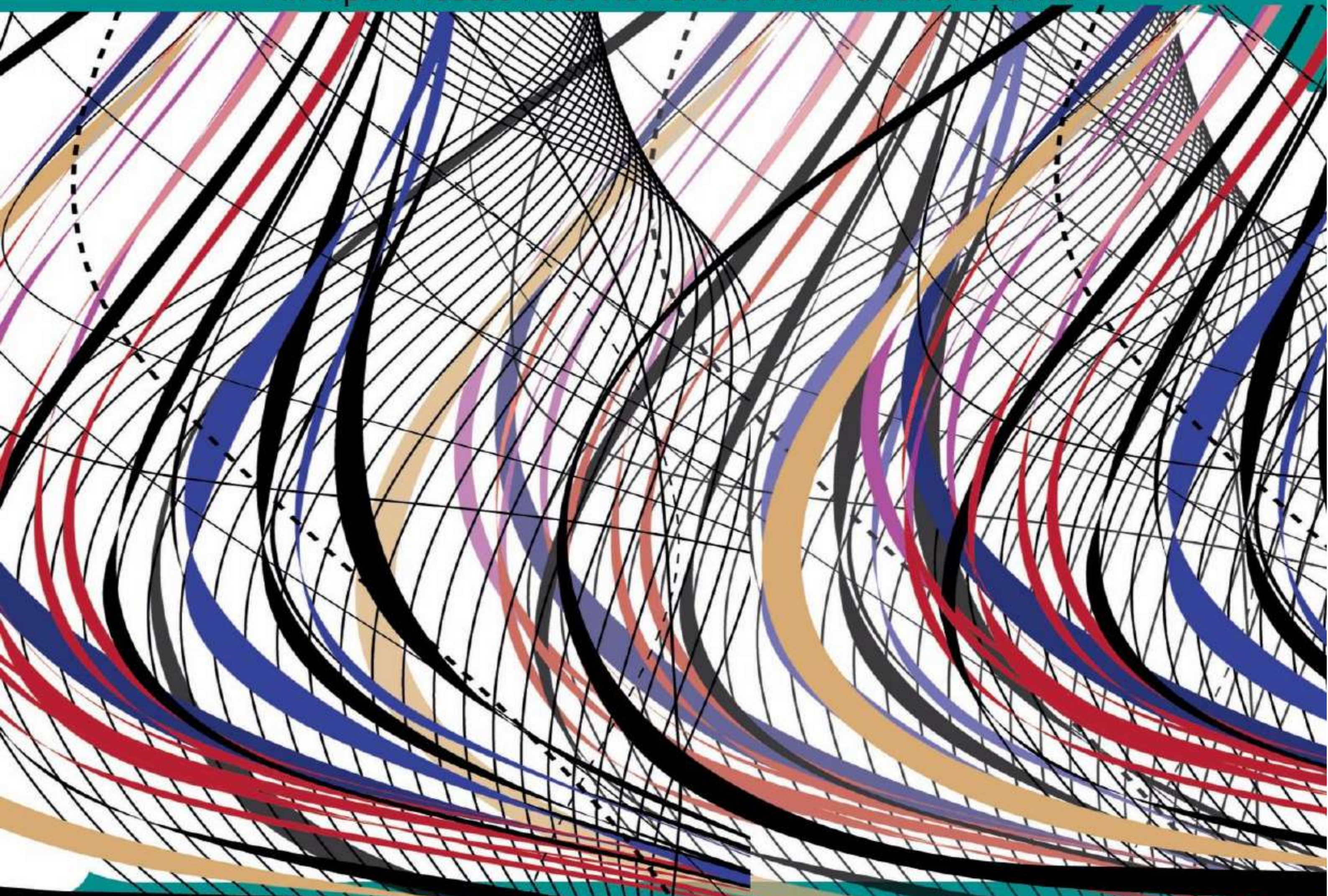

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The Effect of Earthquake-induced Pounding on the Response of a Series of Neighboring Buildings

Beshoy Mosa[*1], Hytham Elwardany[2], M. Diaa Eldin Khedr[3] ,Ayman Seleemah[4]

[1,3] Department of Basic Engineering sciences, Benha Faculty of Engineering, Benha University, Egypt
[2] Structural Engineering Department, Faculty of Engineering, Delta University for Science and Technology, Egypt
[4] Structural Engineering Department, Faculty of Engineering, Tanta University, Egypt

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Abstract— *The phenomenon of pounding that occurs during earthquakes for adjacent buildings may cause severe damage to the structure and may cause a complete collapse of the structure. This paper aims to make a comparison between the practical and theoretical results resulting from the work of Matlab Code, taking into account the calculation of the pounding force between adjacent towers, and study the effect of changing the coefficient of restitution on the acceleration time history and pounding force between adjacent buildings, study the peak impact force with respect to the stiffness of impact spring element. An impact simulation is carried out numerically using a nonlinear viscoelastic model. The results showed that the higher the coefficient of restitution, the lower the pounding forces between adjacent buildings and the maximum acceleration value. It also resulted from the study that the higher the impact stiffness parameter, the greater the pounding force between adjacent buildings.*

Keywords— ***Coefficient of restitution, Pounding force, Seismic analysis, Series of buildings.***

I. INTRODUCTION

Due to the rise in population and the limited amount of available land space in crowded metropolitan areas, buildings are positioned close to one another. High-height buildings have historically housed offices for businesses, but recent years have seen a growth in residential use [1]. With the construction of modern structures, that are built close together, the pounding of structures is becoming a new essential commodity. The word "pounding" is used by previous researchers [2-6] to describe when two neighbouring constructions are close to one another and collide as a result of lateral loading. Previous researchers have also referred to "pounding of structures" as contact between neighbouring structures [7, 8]. Due to their out-of-phase vibration brought on by earthquake stimulation (i.e., mass or rigidity) clash. Similar to Jankowski [9],[10] characterised structural hammering as out-of-phase vibrations that can also happen during high wind conditions. According to previous field evidence, the pounding phenomenon has caused light to substantial structural damage that has even led to widespread structural collapses [11]. Numerous academics have in the past examined these pounding events in great detail, especially in relation to previous earthquake occurrences [4, 5, 9, 11-15]. To comprehend the pounding behaviour, a number of numerical studies have been carried out using various numerical simulation modelling techniques. For instance, Jankowski (2005a) [16] used a nonlinear viscoelastic model to simulate the impact force between two nearby single-degree-of-freedom systems. Since it was discovered that it has a substantial impact on how they collide, the study supported the significance of the natural frequencies of nearby buildings. Miari et al. [17] investigated the seismic pounding between nearby structures with various base conditions. [18]. The study of the mutual pounding of multistory buildings was another area of focus. For instance, Anagnostopoulos and Spiliopoulos explored the pounding between multi-story structures using multi-degree-of-freedom (MDOF) systems with lumped mass at each story level (1992). The findings supported the hypothesis that substantial overstresses could emerge from pounding in the event of unequal building heights. Maison and Kasai (1992) [4] investigated the impact of two nearby structures that were each 8 stories and 15 stories tall. The investigation comprised formulating and resolving the MDOF systems' motion equations that represented the examined buildings. Karayannis and Favvata investigated the ductility requirements as well as the seismic pounding response of reinforced concrete structures with unequal heights (2005)[19]. significant rise in the ductility requirements for the building's taller columns [18]. Numerous researches used numerical and experimental methodologies to simulate the structural pounding behavior during lateral excitation [20, 21] and experimental approaches [22-25]. Studies using single-degree-of-freedom (SDOF) systems have explored the response of buildings to pounding with the aid of numerical analysis [24, 26] and one-directional research [27-30]. Other research has modified their structural pounding evaluation through the use of several degrees of freedom (MDOF) [31-34]. Among the experimental studies that were conducted on three adjacent towers with SDOF is El-Khoriby [34]. Three tower models with varying frequencies were used in the investigation. The towers were tested in two different configurations. In the first arrangement, a rigid tower was positioned in the center of two flexible structures. The conclusions of the experimental study clearly show that pounding may have a major effect on the behaviour of the structures. Because they serve as stoppers for the flexible constructions, they also demonstrate that the rigid towers are more affected by pounding than the flexible ones.

In this paper, a comparison is made between the experimental and numerical studies for three adjacent buildings [34] and the effect of variance on the coefficient of restitution.

II. MATHEMATICAL MODEL

A series of adjacent buildings that have been modelled as elastic SDOF systems are taken into account in the current investigation. The generic dynamic equation of motion (see Fig. 1) that describes the collection of buildings is expressed as:

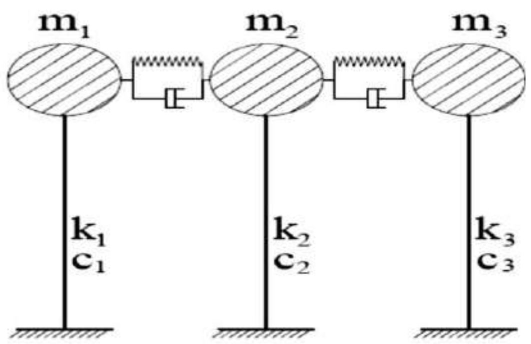


Fig. 1. Mathematical model for a series of three adjacent structures

$$[m]\{\ddot{x}(t)\} + [c]\{\dot{x}(t)\} + [k]\{x(t)\} + \{f_{imp.}(t)\} = -[m]\{\ddot{x}_g(t)\} \quad (1)$$

Where $\{\ddot{x}_g(t)\}$ is the acceleration vector of the input ground motion and $\{f_{imp.}(t)\}$ is the impact force vector for the colliding adjacent buildings, and $\{x(t)\}$, $\{\dot{x}(t)\}$, $\{\ddot{x}(t)\}$ are the displacement, velocity, and acceleration vectors, respectively; $[m], [c]$ and $[k]$ are the mass, damping, and stiffness matrices, respectively, for buildings.

$$[m] = \begin{bmatrix} m_1 & 0 & 0 \\ 0 & m_2 & 0 \\ 0 & 0 & m_3 \end{bmatrix}, \{\ddot{x}(t)\} = \begin{Bmatrix} \ddot{x}_1(t) \\ \ddot{x}_2(t) \\ \ddot{x}_3(t) \end{Bmatrix},$$

$$[c] = \begin{bmatrix} C_1 & 0 & 0 \\ 0 & C_2 & 0 \\ 0 & 0 & C_3 \end{bmatrix}, \{\dot{x}(t)\} = \begin{Bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \\ \dot{x}_3(t) \end{Bmatrix},$$

$$[k] = \begin{bmatrix} k_1 & 0 & 0 \\ 0 & k_2 & 0 \\ 0 & 0 & k_3 \end{bmatrix}, \{x(t)\} = \begin{Bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{Bmatrix} \text{ and}$$

$$\{f_{imp.}(t)\} = \begin{Bmatrix} f_{imp.1}(t) \\ f_{imp.2}(t) - f_{imp.1}(t) \\ -f_{imp.2}(t) \end{Bmatrix}$$

The contact element is activated when there is an impact in the pounding model, which is based on contact force. The non-linear damper is only triggered during the approach phase of a collision, and the contact element is thought to be a Hertzdamp model (Non-Linear Viscoelastic Model) where a non-linear spring applying the Hertz law of contact is applied. When two nearby constructions collide, the impact force is stated as follows:

$$F_{imp.i}(t) = 0 \quad \text{for } \delta(t) \leq \quad \text{(no contact)} \quad (2\text{-a})$$

$$F_{imp.i}(t) = \bar{\beta}\delta^{\frac{3}{2}}(t) + \bar{c}(t)\dot{\delta}_{ij}(t) \text{ for } \delta(t) > 0 \text{ and } \dot{\delta} > 0 \quad (2\text{-b})$$

$$(\text{contact} - \mathit{approach\ period})$$

$$F_{imp.i}(t) = \bar{\beta}\delta^{\frac{3}{2}}(t) \text{ for } \delta(t) > 0 \textit{ and } \dot{\delta} \leq 0 \quad (\text{contact} - \text{restitution period}) \qquad (2\text{-c})$$

where $\delta(t)$ describes the deformation of the colliding structures, $\dot{\delta}_{ij}(t)$ denotes the relative velocity between them and may be expressed as following:

$$\delta(t) = x_1(t) - x_2(t) - d \ ;$$

$$\bar{c}(t) = 2\bar{\xi}\sqrt{\bar{\beta}\sqrt{\delta(t)}\frac{m_1 m_2}{m_1 + m_2}} \qquad (3)$$

where m_1 and m_2 are the masses of colliding structures, and $\bar{\beta}$ is the impact stiffness parameter. It depends on the geometry and material properties of the colliding structures, and it is considered to be $2.75\text{x}10^9$ $N/m^{3/2}$ see, Jankowski [35]. Moreover, d is the initial gap distance, and $\bar{\xi}$ is the impact damping ratio. It can be obtained as following:

$$\bar{\xi} = \frac{1 - c_r}{c_r^{(\alpha+0.204)} + 3.351 c_r \pi} \ ; \quad \alpha = 1.05{c_r}^{0.653} \qquad (4)$$

where c_r is the coefficient of restitution, which accounts for the amount of dissipated energy during impact. It depends on both the geometry and the material properties of the impacting surfaces and on the value of the relative prior-impact velocity of colliding surfaces, $\ddot{x}_g(t)$ is the acceleration of the ground motion [36].

III. VERIFICATION WITH PREVIOUS STUDIES

The efficiency of the model used in the current research was tested by comparing its results with the experimental results reported by [34]. Three adjacent SDOF buildings (see Fig. 2) with structural properties shown in Table 1 were experimentally tested under the 1989 Loma Prieta, NS (Corralitos station) with an amplification of 50% from ground motion data. The coefficient of restitution "c_r" is considered to be 0.4; see [36].

Table 1. Characteristics of different buildings see [34].

	Tower 1	Tower 2	Tower 3
Mass (kg)	90.5	48	90.5
Stiffness (N/m)	18532.5	19390.8	18532.5
Time period T(s)	0.439	0.31	0.439
Damping ratio (%)	0.34	0.25	0.38

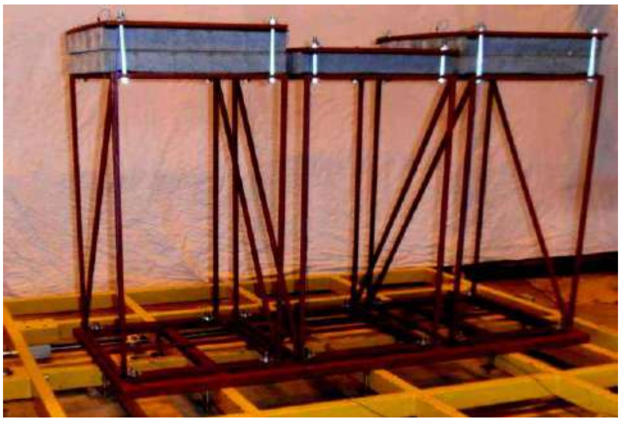
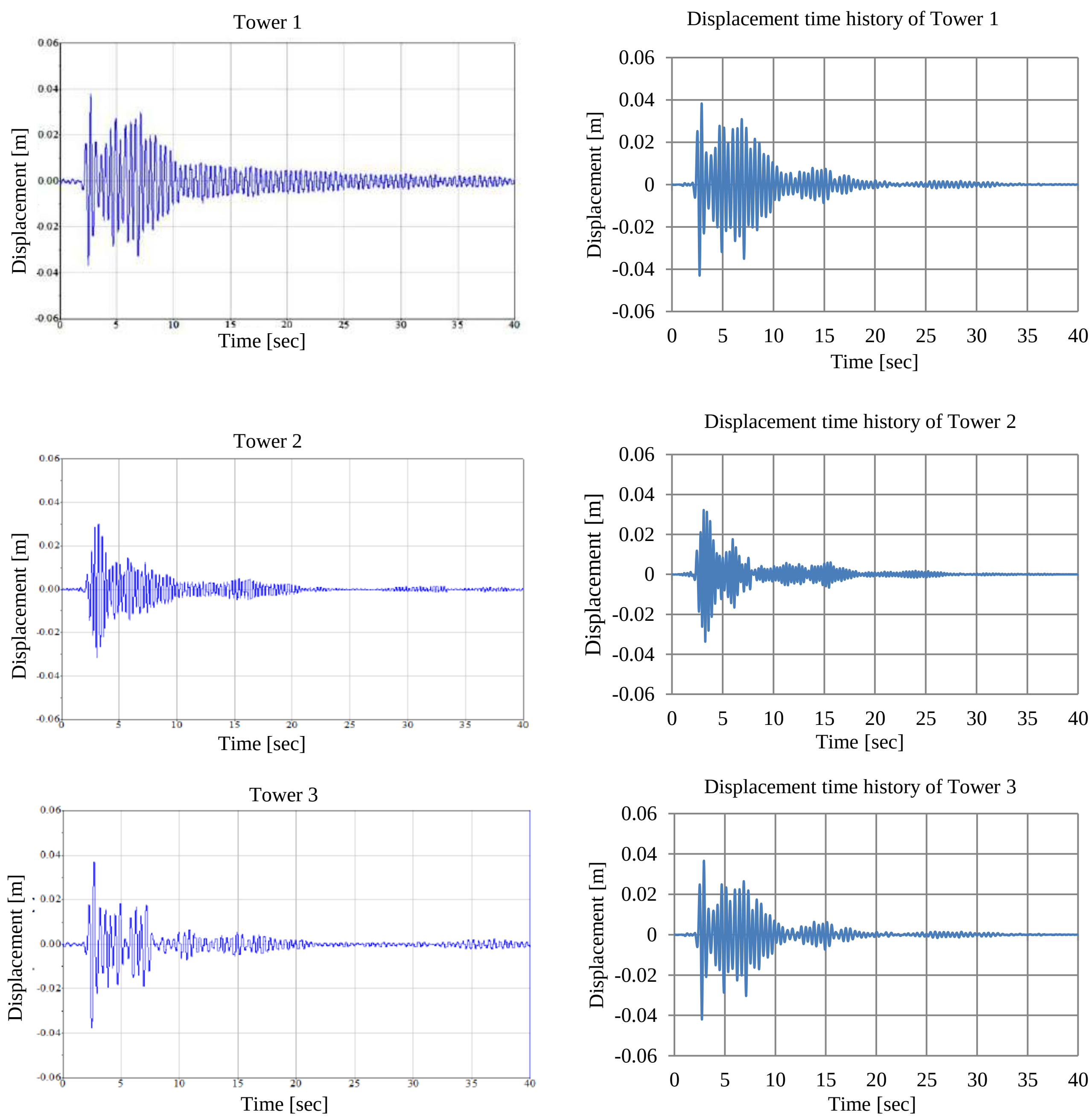


Fig. 2. Experimental study carried out by El-Khoriby et al. (2015)

Fig. 3 shows a comparison between the displacement time history for the independent behaviour (gap size =6 cm) for experimental and numerical studies.



a b

Fig. 3. displacement time history for independent behavior (a) The experimental study El-Khoriby et al. (2015), (b) the numerical study

Fig. 4 shows the acceleration time history for three adjacent buildings in the case of a gap size of 4 cm.

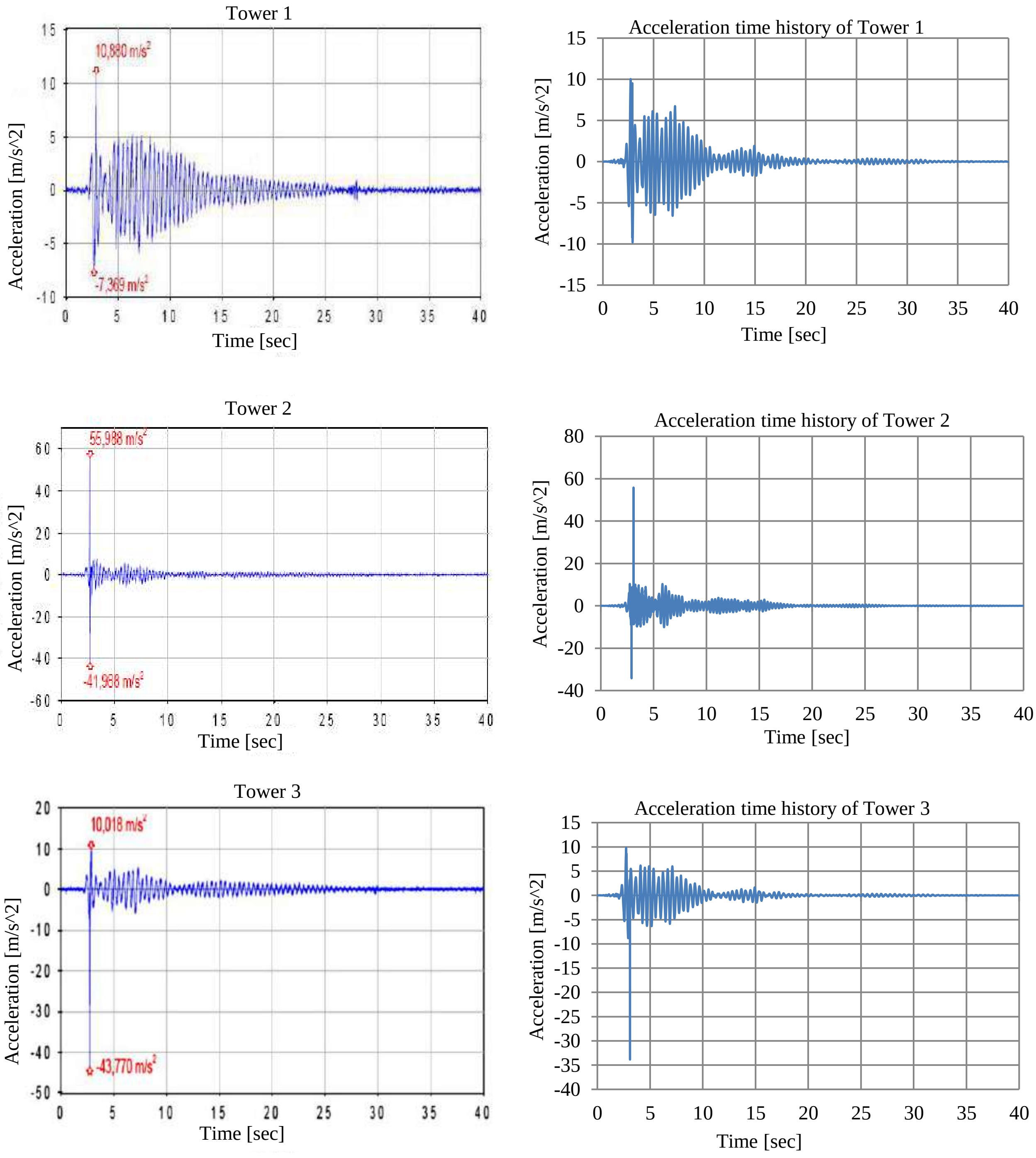


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Fig. 4. Acceleration time history for independent behaviour (a) The excremental study El-Khoriby et al. (2015), (b) the numerical study

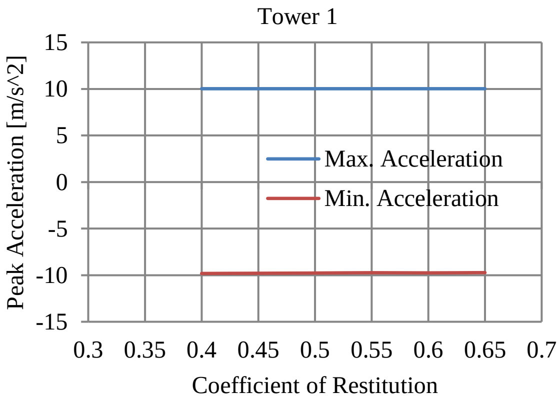
This comparison shows that the results from the mathematical model give a good result when compared to the experimental study. Table 2 shows the difference ratio between the experimental and the numerical study.

Table 2. The difference ratio between the experimental and the numerical study

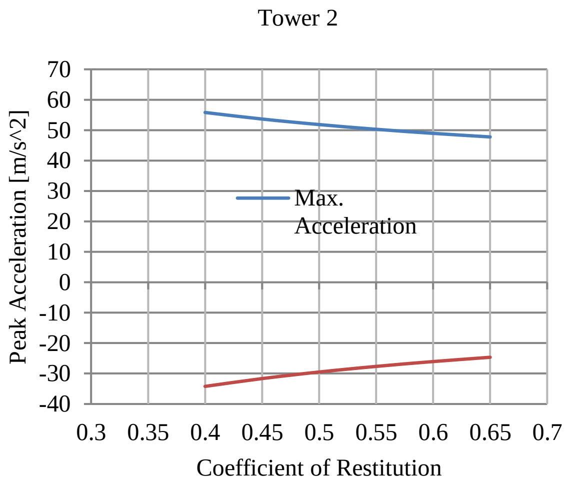
case	Max. displacement for the Independent case (gap size 6 cm)		Difference (%)	Max. acceleration for the Pounding case (gap size 4 cm)		Difference (%)
	Experimental	Numerical		Experimental	numerical	
Tower 1	0.038	0.042	10.53	10.88	10.02	7.9
Tower 2	0.032	0.033	3.1	55.98	55.8	0.32
Tower 3	0.037	0.041	10.8	43.77	33.86	22.6

IV. EFFECT OF COEFFICIENT OF RESTITUTION

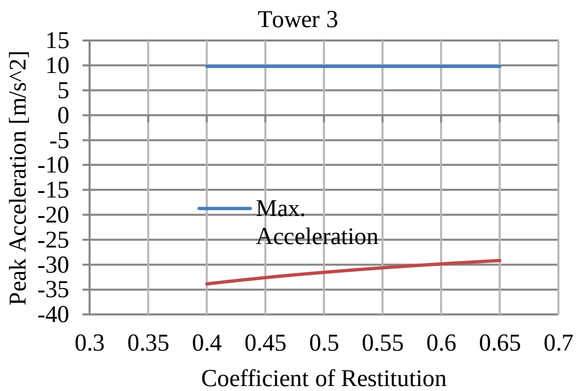
A study was conducted to determine how the coefficient of restitution affected the structural response. In this parametric study, we will study the effect of changing the coefficient of restitution on the seismic response (Acceleration time history) and on the pounding force. Different values of the coefficient of restitution Cr range from 0.4 to 0.65. Fig. 5 shows the relation between the coefficient of restitution and the peak acceleration for tower 1, tower 2, and tower 3, respectively.



(a)



(b)



(c)

Fig. 5. Peak acceleration with relation to coefficient of restitution for (a) Tower 1, (b) Tower 2, and (c) Tower 3.

The results show a uniform decrease in the peak acceleration when the coefficient of restitution increases; see Fig. 5.

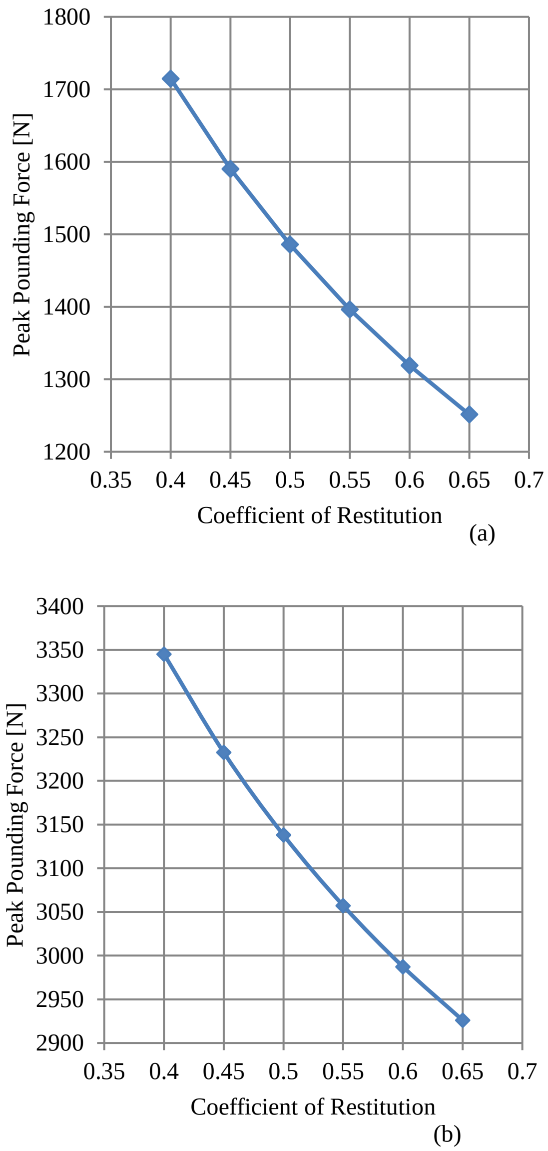


Fig. 6. Peak impact force with relation to coefficient of restitution (a) between Tower 1 and Tower 2; (b) between Tower 2 and Tower 3.

Fig. 6 shows the peak value of impact forces versus the coefficient of restitution. The results show that when the coefficient of restitution increases, the peak impact force decreases uniformly. The peak impact forces between tower 1 and tower 2 are 1715 N, 3445 N for CR = 0.4 and 1251 N, 2926 N for CR = 0.65, respectively.

V. EFFECT OF STIFFNESS OF IMPACT SPRING

The impact stiffness parameter is one of the most significant factors that affect the impact force during a collision. Fig. 7 shows the peak values of impact forces with respect to impact spring stiffness. It can be seen from the figure that the general trend for all impact forces between adjacent towers increases with increasing impact spring stiffness.

Different values of the impact spring stiffness were taken from $1.25 * 10^9$ N/mm^(3⁄2) to $4 * 10^9$N/mm^(3⁄2) the peak impact force between tower 1 and tower 2 show nearly linear increase from 950.09 N to 2295.27 N, while between tower 2 and tower 3 show nearly linear increase from 1674.75 N to 4677.64 N.

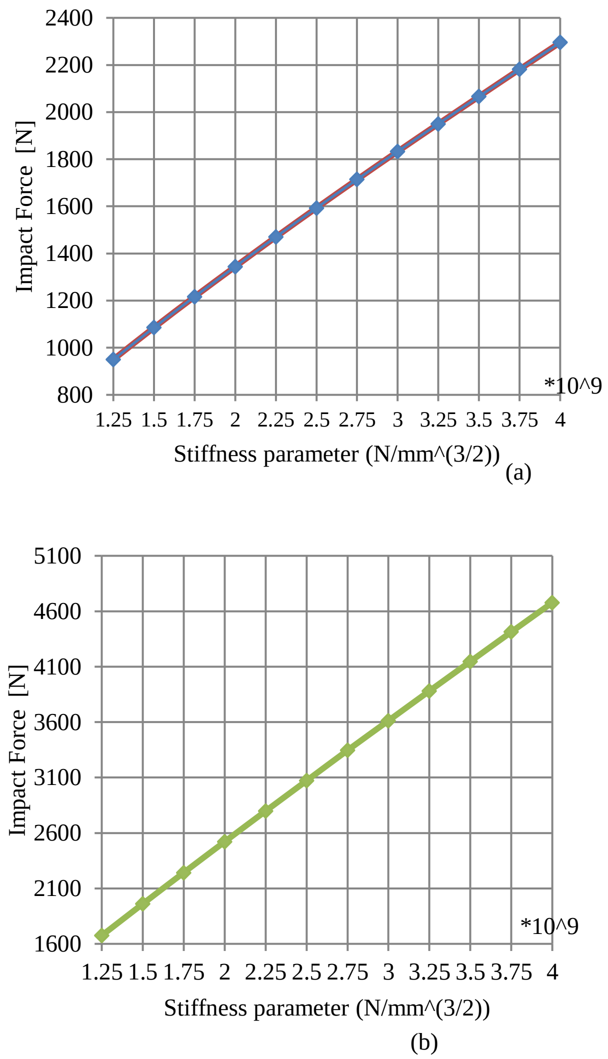


Fig. 7. Peak impact force with respect to impact stiffness (a) between Tower 1 and Tower 2; (b) between Tower 2 and Tower 3.

VI. CONCLUSION

The nonlinear viscoelastic model (Hertzdamp) was used in this study's Matlab code to simulate pounding between a series of three adjacent structures with different natural frequencies. The numerical model was initially verified by contrasting its predictions with the experiment results on three adjacent buildings. The results revealed that the mathematical model is in good agreement with the experimental study. The paper also investigates the effect of different values of the coefficient of restitution on their pounding response, as well as, the effect of different values of the impact spring stiffness on the peak impact force between series of adjacent buildings.

As a general trend, it is observed that, the higher the restitution coefficient, the lower the pounding force between adjacent structures. The coefficient of restitution was changed from 0.4 to 0.65, and it was concluded that the pounding force between the first and second towers decreased in the case of the restitution coefficient of 0.65 by 27% than its value in the case of the restitution coefficient of 0.4 where the pounding force between the second and third towers decreased in the case of the restitution coefficient of 0.65 by 12.5% than its value in the case of the restitution coefficient of 0.4, also. Moreover, the results revealed that, the general trend for all impact forces between adjacent towers increases with increasing impact spring stiffness.

REFERENCES

[1] M.M. Ali, K.S. Moon,(2007) Structural developments in tall buildings: current trends and future prospects, Architectural science review, (50) 205-223.

[2] S.A. Anagnostopoulos, K.V. Spiliopoulos,(1992) An investigation of earthquake induced pounding between adjacent buildings, Earthquake engineering & structural dynamics, (21) 289-302.

[3] B.F. Maison, K. Kasai,(1990) Analysis for a type of structural pounding, Journal of Structural Engineering, (116) 957-977.

[4] B.F. Maison, K. Kasai,(1992) Dynamics of pounding when two buildings collide, Earthquake engineering & structural dynamics, (21) 771-786.

[5] K. Kasai, B.F. Maison,(1997) Building pounding damage during the 1989 Loma Prieta earthquake, Engineering structures, (19) 195-207.

[6] S. Efraimiadou, G.D. Hatzigeorgiou, D.E. Beskos,(2013) Structural pounding between adjacent buildings subjected to strong ground motions. Part I: The effect of different structures arrangement, Earthquake Engineering & Structural Dynamics, (42) 1509-1528.

[7] C.G. Karayannis, M.J. Favvata,(2005) Inter-story pounding between multistory reinforced concrete structures, Structural engineering and mechanics: An international journal, (20) 505-526.

[8] M.J. Favvata, C.G. Karayannis, V. Anagnostopoulou, Influence of infill panels with and without openings on the pounding effect of RC structures, in.

[9] R. Jankowski,(2009) Non-linear FEM analysis of earthquake-induced pounding between the main building and the stairway tower of the Olive View Hospital, Engineering Structures, (31) 1851-1864.

[10] M.M. Abdullah, J.H. Hanif, A. Richardson, J. Sobanjo,(2001) Use of a shared tuned mass damper (STMD) to reduce vibration and pounding in adjacent structures, Earthquake engineering & structural dynamics, (30) 1185-1201.

[11] E. Rosenblueth, R. Meli,(1986) The 1985 mexico earthquake, Concrete international, (8) 23-34.

[12] S.A. Anagnostopoulos,(1988) Pounding of buildings in series during earthquakes, Earthquake engineering & structural dynamics, (16) 443-456.

[13] R. Jankowski,(2012) Non-linear FEM analysis of pounding-involved response of buildings under non-uniform earthquake excitation, Engineering Structures, (37) 99-105.

[14] H.B. Kaushik, K. Dasgupta, D.R. Sahoo, G. Kharel,(2006) Performance of structures during the Sikkim earthquake of 14 February 2006, Current Science, 449-455.

[15] T. Brown, A. Elshaer,(2022) Pounding of structures at proximity: A state-of-the-art review, Journal of Building Engineering, (48) 103991.

[16] R. Jankowski, Impact force spectrum for damage assessment of earthquake-induced structural pounding, in, Trans Tech Publ, pp. 711-718.

[17] M. Miari, K.K. Choong, R. Jankowski,(2019) Seismic pounding between adjacent buildings: Identification of parameters, soil interaction issues and mitigation measures, Soil Dynamics and Earthquake Engineering, (121) 135-150.

[18] H. Elwardany, B. Mosa, M. Khedr, D. Eldin, A. Seleemah,(2022) Effect of earthquake induced-pounding on the response of four adjacent buildings in series, STRUCTURAL ENGINEERING AND MECHANICS, (83) 153-166.

[19] C.G. Karayannis, M.J. Favvata,(2005) Earthquake-induced interaction between adjacent reinforced concrete structures with non-equal heights, Earthquake engineering & structural dynamics, (34) 1-20.

[20] J.P. Conoscente, R.O. Hamburger, J.J. Johnson, Dynamic analysis of impacting structural systems, in, AA Balkema Rotterdam, pp. 3899-3903.

[21] S. Muthukumar, R. DesRoches,(2006) A Hertz contact model with non-linear damping for pounding simulation, Earthquake engineering & structural dynamics, (35) 811-828.

[22] A. Rezavandi, A.S. Moghadam,(2007) Experimental and numerical study on pounding effects and mitigation techniques for adjacent structures, Advances in Structural Engineering, (10) 121-134.

[23] M. Papadrakakis, H.P. Mouzakis,(1995) Earthquake simulator testing of pounding between adjacent buildings, Earthquake engineering & structural dynamics, (24) 811-834.

[24] K.T. Chau, X.X. Wei,(2001) Pounding of structures modelled as non-linear impacts of two oscillators, Earthquake engineering & structural dynamics, (30) 633-651.

[25] R. Jankowski, A. Seleemah, S. El-Khoriby, H. Elwardany, Experimental study on pounding between structures during damaging earthquakes, in, Trans Tech Publ, pp. 249-252.

[26] C.P. Pantelides, X. Ma,(1998) Linear and nonlinear pounding of structural systems, Computers & Structures, (66) 79-92.

[27] P. Komodromos,(2008) Simulation of the earthquake-induced pounding of seismically isolated buildings, Computers & Structures, (86) 618-626.

[28] K. Bi, H. Hao, N. Chouw,(2010) Required separation distance between decks and at abutments of a bridge crossing a canyon site to avoid seismic pounding, Earthquake Engineering & Structural Dynamics, (39) 303-323.

[29] A. Sarebanha, G. Mosqueda, M.K. Kim, J.H. Kim, Effects of moat wall impact on the seismic response of base isolated nuclear power plants, in.

[30] A. Sarebanha, G. Mosqueda, M.K. Kim, J.H. Kim,(2018) Seismic response of base isolated nuclear power plants considering impact to moat walls, Nuclear Engineering and Design, (328) 58-72.

[31] C.M. Chan,(2001) Optimal lateral stiffness design of tall buildings of mixed steel and concrete construction, The Structural Design of Tall Buildings, (10) 155-177.

[32] H. Elwardany, A. Seleemah, R. Jankowski,(2017) Seismic pounding behavior of multi-story buildings in series considering the effect of infill panels, Engineering Structures, (144) 139-150.

[33] H. Elwardany, A. Seleemah, R. Jankowski, S. El-Khoriby,(2019) Influence of soil–structure interaction on seismic pounding between steel frame buildings considering the effect of infill panels, Bulletin of Earthquake Engineering, (17) 6165-6202.

[34] S. El-Khoriby, A. Seleemah, H. Elwardany, R. Jankowski, Experimental and numerical study on pounding of structures in series, in: Advances in Structural Engineering, Springer, 2015, pp. 1073-1089.

[35] R. Jankowski,(2005) Non-linear viscoelastic modelling of earthquake-induced structural pounding, Earthquake engineering & structural dynamics, (34) 595-611.

[36] S.M. Khatami, H. Naderpour, R.C. Barros, A. Jakubczyk-Gałczyńska, R. Jankowski,(2019) Determination of peak impact force for buildings exposed to structural pounding during earthquakes, Geosciences, (10) 18.

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Ecological Study Along the Highlands Highway in Papua New Guinea

Nguyen Thu Ha

Ecology Faculty, RUDN, Moscow, Russia

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***Abstract*— *This ecological survey carried out along the Highlands Highway (71 locations-bridges) between Erap Bridge in Morobe Province to Whagi Bridge, Western Highlands Province. Data and information collection involved physical site observations and informant interviews. The survey used the capture-release method for insects, invertebrates, fish, and plankton; flyover counts were used for birds and informant interviews for mammals and other animals of interest. Terrestrial ecosystem: Common fauna included invertebrates such as Eurema hecabe, Danaus plexippus, Plutella xylostella, and other types of butterflies, Anisoptera, Apis cerena, and black ants (Fomicidae). Vertebrates such as sparrows (Passeridae), willy wagtail (Rhipidura leucophrys), eagle (Hieraaetus weiskei), kingfisher (Alcedinidae), mountain cuscus (Phalanger carmelitae), tree kangaroo (Dendrolagus goodfellowi) and Princess Stephanie's Astrapia (Astrapia. Stephaniae). Flora across the highlands province commonly appeared bamboo, casuarina oligodon (she-oak), Ficus dammaropsis, coffee, elephant grass (Pennisetum purpureum), cow grass (Axonopus compressus), rain tree (Samanea saman), Piper adancum and banana. In contrast, common and significant flora along plain region included casuarina, pine, leucaena, bamboo, and other anthropogenic grasses, Piper adancum, sunflower (Helianthus annuus), Northofagus grandis, and Ficus. Aquatic ecosystem: Aquatic fauna along the highlands region included carp (Cyprinidae), tilapia (Oreochromis mossambica), juvenile fish, freshwater prawns (Palaemonidae), trout (Oncorhynchus mykiss), and catfish (Arius spp) while aquatic fauna of coastal province comprised of invertebrates like pond skaters, water beetle and tadpoles and invertebrates such as rainbow trout and tilapia. Aquatic flora was limited to green algae at a few locations in the highlands provinces where the water was stagnant or had human impacts, but it was primarily green and brown algae in the plain area. We also found Dendrolagus goodfellowii as an endangered species, while Phalanger carmelitae, Astrapia stephaniae, and Northofagus grandis are endemic but classified as the least concern. The findings indicated modification of habitats throughout the Highlands Highway. The absence of native and endemic species was also noted in most of the locations. Only six sites revealed some primary and secondary forests and vegetation.**

***Keywords*— Environmental impact, Highlands Highway, Papua New Guinea.**

I. BACKGROUND

The Highlands Highway in Papua New Guinea passes through the coastal province of Morobe to the mountainous Highlands Provinces of Eastern Highlands, Western Highlands, Southern Highlands, Enga, Jiwaka, Hela, and Simbu, which is a densely populated region with a population of over 2.9 million (Census, 2011). The area is spread in its ecology as it ranges from the highest peak at Mt Wilhelm in the Simbu province at 4,509m above sea level to the lowlands of Kutubu Lake area in the Southern Highlands Province. The provinces of Eastern Highlands, Simbu, Jiwaka, and Western Highlands, where the Highlands Highway passes through, fall into the two ecoregions (Morrison, 2000).

The region is part of the Central Cordillera that outlines two ecoregions of interest, namely the Central Range

Montane Rain Forests and the Central Range Sub-Alpine Grasslands (Morrison, 2000). Critical areas are part of this region and considered areas of high biodiversity priority (WWF, 2021).

In addition, most of these critical areas also form part of the Protected Area network or system, as indicated on the map in *Fig.1*.

Fig.1. Map of Protected Areas in Papua New Guinea

Source: WWF

A critical protected area in Morobe Province that contributes to conserving the endangered Matchies Tree Kangaroo is the YUS conservation area (Refer to Map in *Fig.1*). It is a newly established Conservation Area located several kilometers inland in the Kabwum district, far from parts of Huon Gulf and Markham districts through which the Highlands Highway passes.

Typical fauna of the highlands region includes Raggianna bird of paradise (*Paradisaea raggiana*) and the Princess Stephanie Astrapia (*Astrapia stephaniae*) as well as mountain cuscus (*Phalanger carmelitae*) and good fellows tree kangaroos (*Dendrolagus goodfellowi*). Some important flora species include *Nothofagus grandis*.

To better understand the impacts of traffic development to the ecosystem, we have conducted a survey on the status of the ecosystem along the Highlands Highway (430 km) starts from the coastal province to the Highlands provinces.

II. METHODOLOGY

A survey, including data collection and analysis, was carried out between Erap River Bridge (Km 46 + 500) and Whagi River Bridge (Km 463+900) by the Team comprising surveyors covering vegetation; invertebrates, insects, and plankton; fish, frogs, reptiles, birds, and mammals.

Each surveyor was allocated a set of forms to complete for different categories as listed (See **Error! Reference source not found.** for samples). A summary of each category was then compiled to provide an overview of each site.

2.1. Site location and description

A total of 71 locations (bridges) were surveyed from Erap River Bridge (Km 46+500) to Whagi River Bridge Km 463+900 (B#71). The first 19 locations from Erap River Km 46+500 (B#1) to Yung Creek Km 167+100 (B#19) are in Morobe Province while the other 35 locations from Undono Creek Km 178+000 (B#20) to Baikabai River Km 348+400 (B#54) belongs to Eastern Highlands Province, and from Simbu river Km 376+700 (B#55) to Garniger River Km 401+500 (B#58) are in Simbu province (4 locations), from Miunde River Km 404+500 (B#59) to Komun River Km 462+100 (B#70) are in Jiwaka province (12 locations), and the last location is Whagi River Bridge Km 463+900 (B#71) in Western Highlands Province. The plots and locations are shown in *Fig.2*.

Fig.2. Map showing locations of survey

2.2. Data Collection Methods

The description of the vegetation and the measure of human interactions on the environment were observed and recorded for each location. These details were recorded on the survey forms used by each surveyor (See copy in **Error! Reference source not found.**). Field guides on the fauna and flora of Papua New Guinea, as well as general information on invertebrates and insects, were also used to assist the surveyors in identifying the species. The details of each survey method used are described below.

2.2.1. Methods for Terrestrial ecosystem

Fauna. The data on insects and invertebrates, such as butterflies, dragonflies, bees, and common flies, were gathered through the physical sighting of organisms. These were further observed through capturing the organisms, closely observing and recording their details, and releasing them into their environment. For water-tolerant birds, flyover counts, as well as their calls, were recorded. The flyover count involved close observation of the bird that flew near or around the location. It enabled the observers to take note of the details of the bird, including its color, size, and type. Birdcalls were also used to identify the bird type. Information about other animals that were not sighted at the time of the survey was gathered through informant interviews. A total of 62 informant interviews were conducted out of the 71 locations surveyed.

Flora. At each site, there was a physical observation of the surrounding vegetation. A physical count of common trees and plant species was carried out to determine their availability. Photographs of plant and tree species were also captured, and a field guide on the Flora of Papua New Guinea was also used to identify common species.

2.2.2. Methods for Aquatic ecosystem

Fauna. The data and information on fish and other aquatic invertebrates were gathered through three main methods - physical sighting of organisms, capture release, and informant interviews. Physical sighting and capture release were used for juvenile fish, prawns, pond skaters, mollusks, and water beetles. These were caught with a net, observed, and released back into the water. For zooplankton, water samples were collected, and a hand lens was used to look at this sample. This was then poured back into the water. Due to the timing of the surveys, informant interviews were also carried out to establish other kinds of fish and aquatic fauna present in each location. Again, a total of 62 interviews were conducted.

Flora. Data for aquatic flora was gathered through physical sightings of water in each location. A water sample was also collected at each site and checked using a hand lens to identify any signs of phytoplankton.

Water, air, and ground temperatures were also recorded to observe any effect on the availability of organisms at different times of the day.

III. RESULT AND DISCUSSION

3.1. Results

The survey found that most of the habitats along the Highlands Highway have had some human impact that modifies the environment and its vegetation. Human settlements in or near the road have changed the ecosystems through clearing for gardening, house construction, washing, and other daily activities. Of these, the environments at two locations - Clean Water River Bridge Km77+800 (B#4) and GorambamPam River Bridge Km113+000 (B#6) - were found to have little or no human impact, thus, appearing to be more natural. Feonoku River Km335+450 (B#51) has a high montane type of vegetation with very short shrubs and trees with a lesser human impact on the environment. Nurape River Km342+850 (B#52), Kenangi River Km345+200 (B#53), and Baikabai River Km348+400 (B#54) - still have some primary and secondary forests near the mountains close to the bridges. All four locations are located within Watabung in the Daulo District of Eastern Highlands Province, where steep mountains rise from the side of the road with the Highway running through these narrow passages. Villages also appear on the roadsides along the Highway.

Four (4) locations - Zumin River Km133+00 (B#10), Yafatz River Km137+100 (B#1), Bintia River Km151+000 (B#13) and Utwini River Km157+150 (B#15) - all located in the Markham Plains in Morobe Province had little or no data for the aquatic ecosystem. The riverbanks were dried up during the survey due to the dry season. The Markham Plains experiences fluctuating weather conditions that bring long periods of wet or dry spells. These seasons are also influential on the conditions of the Highway. Along the Highway, aquatic flora is primarily green and brown algae observed in rivers where human activities like swimming, laundry, and waste disposal were high.

In addition, nine (9) locations along this section have evidence of quarry activities on or near the bridge - Bena Bena River Km 280+650 (B#42), Kanalipi River Km 288+100 (B#44), Mapemo River 3 Km 10+900 (B#48), Simbu River Km 376+700 (B#55), Garniger River Km401+500 B#58), Miunde River Km 404+500 (B#59), Ahl River Km 414+150 (B#60), Tumam River Km 449+500 (B#68) and Komun River Km 462+100 (B#70). These locations are spread within all four provinces of Eastern Highlands, Simbu, Jiwaka, and Western Highlands. The quarry activities have modified the riverbeds and the surrounding environments where the natural vegetation has been cleared.

Due to modifications by human activities, the vegetation of these locations is also comprised of introduced and exotic species as well as a few local or native species. Common flora across all locations included elephant grass (*Pennisetum purpureum*), cow grass (*Axonopus compressus*), rain tree (*Samanea saman*), *Piper adancum* and food trees like banana. On locations B#1 to B#19, which are on the coastal side of the Highlands Highway, common flora included betel nut tree (*Areca catechu*), coconut, cogon grass (*Imperata cylindrica*), sensitive grass (*Mimosa pudica*) and food trees such as mango. Also, on locations B#1 and B#6, giant nut grass (*Cypress rotundas*) was recorded. On locations Undono Creek Km 178+000 (B#20) to Baikabai River Km 348+400 (B#54), which are on the Eastern Highlands side of the Highlands Highway, commonly occurring flora included bamboo, *Casuarina* *oligodon* (she-oak), *Ficus dammaropsis* and coffee. These have mostly been planted by local people. Anthropogenic grasses (elephant grass, kunai, pitpit, etc.) are quite common, where human activities have gone on for some time. *Piper adancum* was also common in modified vegetation. The only location with some native species such as *Northofagus grandis* and *Ficus* species that can still be seen include Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53) and Baikabai River Km 348+400 (B#54). Most of these species are located on the sides of the mountains beside the Highway. Aquatic flora is mostly green and brown algae. These were observed in rivers where human activities like swimming, laundry, and waste disposal were high.

Apart from these, a couple of locations had some floral species of interest. At Erap Bridge (B#1), we found the leucaena tree (*Leucaena leucocephala*), which is listed as low risk. Clean water bridge (B#4) has rattan palm (*Korthalsia zippelii*) whose status is unknown. At Ngaraburam River (B#7), we recorded an Erima Tree (*Octomeles sumatrana*), which IUCN lists as the least concern. The tree may have been introduced at this location through other means. At Utwini Bridge (B#15), one *Elaeocarpus* tree was recorded, which could also have been planted or introduced through other means. At Tapiruna (B#21), Luwin (B#23), Orompanka (B#27), and Kingkio Bridges (B#32), *Pandanus julianetti* was recorded, indicating that people may have planted these. Only Ofiga River (B#30) and Umbaka River (B#31) recorded the presence of *Ficus dammaropsis* at the observation location. Ofiga River (B#30 also recorded *Nothofagus grandis*.

Terrestrial fauna besides the Highway was limited to insects and other invertebrates such as butterflies and dragonflies, although the black and white Willy wagtail was commonly sighted near rivers. The most common butterfly sighted in most of the locations in the plain area was the small yellow butterfly (*Eurema hecabe*). Other butterflies such as *Danaus plexippus* and moths such as *Plutella xylostella* also appeared in most of these locations. In contrast, at the locations of the Highlands region, only Kenangi River Km 345+200 (B#53) recorded sightings of four different types of butterflies.

In addition, sparrows (*Passeridae*) were the most common birds in most of the locations, followed by kingfisher (*Alcedinidae*), hawk (*Accipitridae*), and Willy wagtail (*Rhipidura leucophrys*). Mammals, reptiles, and frogs were not sighted during the survey. However, the results of informant interviews indicated that the presence of mammals such as mountain cuscus, tree kangaroos, and Princess Stephanie's astrapia bird of paradise (A. stephaniae) was recorded at Feonoku River Km 355+450 (B#51), Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53), and Baikabai River Km 348+400 (B#54).

Aquatic flora mostly comprised green algae at all sites except B#4, B#5, B#7, B#10, B#15, and B#43.

Aquatic fauna that commonly appeared in most of the locations (B#1 to B#44) included carp (*Cyprinidae*), tilapia (*Oreochromis mossambica*), juvenile fish, and freshwater prawns (*Palaemonidae*). Trout was recorded in B#32, B#33, B#39, B#41, and B#43, while the freshwater turtle was reported only in Ramu River (B#3). Other species of fish such as catfish (*Arius spp*) were only recorded in B#1, B#2, B#3, and B#4 while golden carp and black carp were reported in B#26, B#27, B#28, B#29 and B#30.

3.2. Discussion

The results indicated that all locations from Erap River Bridge (B#1) to Kanalipi River Bridge (B#44) had some human impact which modified most of the environment and ecosystems within them. Only six locations Clean Water River Bridge Km77+800 (B#4), GorambamPam River Bridge Km113+000 (B#6), Feonoku River Km 335+450 (B#51), Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53) and Baikabai River Km 348+400 (B#54) were recorded as having a more natural environment or ecosystem due to none or minimal human impact and appeared to have remnants of primary and secondary montane forests existing on the sides or near the Highway. These sites were also noted to have a variety of terrestrial fauna and native or local species. For example, over 24 species were recorded, rattan palm (*Korthalsia zippelii*) was only recorded in Clean Water River Km77+800 (B#4).

A summary of the discussions about the species and their presence or absence are discussed below.

3.2.1 Terrestrial ecosystem

Fauna

Common terrestrial fauna identified included invertebrates such as *Eurema hecabe*, *Anisoptera*, *Apis cerena*, *Fomicidae*, *Plutella xylostella, and* other butterflies of various colours and sizes such as Monarch butterfly (*Daanaus plexippus*). Presence of these invertebrates may be attributed to their preference of water in their ecology. Birds that were commonly sighted included sparrows (*Passeridae*), hawk (*Accipitridae*), eagle (*Hieraaetus weiskei*), kingfisher (*Alcedinidae*), and Willy wagtail (*Rhipidura leucophrys*). These birds are also identified as common in open grasslands and rivers.

Generally, no mammals, frogs, and reptiles were observed in all these locations except the ones reported by the informant interviewees. Informant interviews indicated that mountain cuscus (*Phalanger carmelitae*[1]), exists in the mountains near Feonoku River Km 355+450 (B#51). These mountains are higher up and not very close to the Highway. This is because the *P. carmelitae* needs trees to move on and with lesser tall trees at the bottom of the mountains near Feonoku River, they will not be easily harmed. Moreover, Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53) and Baikabai River Km 348+400 (B#54) were all reported by informant interviews as having some local mammal and bird species such as mountain cuscus (*Phalanger carmelitae*), tree kangaroo (*Dendrolagus goodfellowi*[2]) and Princess Stephanie's Astrapia (*Astrapia. stephaniae*[3]) in the mountains near the Highway. While *P. carmelitae* and *A. stephaniae* are listed by IUCN as of least concern, *D. goodfellowi* is listed as endangered due to overhunting.

Flora

Common terrestrial flora from B#1 to B#44 included elephant grass (Pennisetum purpureum), cow grass (Axonopus compressus), rain tree (Samanea saman), Piper adancum, and banana. Coastal locations on B#1 to B#19 also recorded typical coastal flora such as betel nut tree (Areca catechu), coconut, cogon grass (Imperata cylindrica), sensitive grass (Mimosa pudica), and mango. On locations from B#20 to B#44, commonly existing highland flora included bamboo, Casuarina oligodon (she-oak), Ficus dammaropsis, and coffee, while casuarina oligodon (she-oak), klinki pine trees, bamboos, Piper adancum, and anthropogenic grasses were quite common in all locations B#45 to B#71

Rare occurrences of the flora of interest, such as Leucaena leucocephala in B#1, Korthalsia zippelii in B#6, Octomeles sumatrana in B#7 and Elaeocarpus in B#15, imply that they could have been distributed via another medium as they are not common grassland flora. According to IUCN, Korthalsia zippelii is unknown, although it is commonly distributed in the lowlands of continental Asia and Malesian region (Barfod, Banka & Dowe, 2001). Similarly, Leucaena leucocephala and Octomeles sumatrana are the least concern.

On the highlands side, the occurrence of *Pandanus julianetti* in B#21, B#23, B#27, and B#32 and *Ficus dammaropsis* in B#30 and B#31 imply that they were introduced by people. In addition, near Ofiga River Bridge Km 223+900 (B#30), Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53) and Baikabai River Km 348+400 (B#54) found *Nothofagus grandis*[4] and a couple of Ficus species also implicate a human origin. Of these, N. grandis has been recorded as the least concern on the IUCN Red list.

3.2.2 Aquatic ecosystem

Fauna

Common aquatic fauna along plain region included carp (*Cyprinidae*), tilapia (*Oreochromis mossambica*), juvenile fish and freshwater prawns (*Palaemonidae*). Trout (*Oncorhynchus mykiss*) was recorded in B#32, B#33, B#39, B#41 and B#43 while catfish (*Arius spp*) was only recorded in B#1, B#2, B#3 and B#4. Golden carp and black carp were also reported in B#26, B#27, B#28, B#29 and B#30. The findings imply that most of these species are common and were introduced into the locations.

The aquatic fauna identified in highlands locations were also generally common and included organisms such as small brown mollusk, water beetle, pond skaters, rainbow trout *(Oncorhynchus mykiss)*, and tilapia (*Oreachromis mossambica*). *O.mykiss* and *O.mossambica* are both introduced species and hence are common.

Washing and domestic waste disposal also affected the water quality resulting in the growth of both brown and green algae in the water that affected the existence of aquatic fauna which were not easily visible at the time of the survey.

Flora

There was no unique or threatened aquatic flora recorded in all locations. The most common was brown and green algae, which also depended on the quality of the river. That is the higher river water usage, the more availability of algae.

In addition, locations with aggravated human impact, such as quarries, clearly showed high modification of the vegetation and the surrounding environment that also affected the type of organisms and flora present in the area. Other activities, such as washing and domestic waste disposal, also affected the water quality resulting in the growth of brown and green algae in the water.

The survey along the Highway showed that human impacts affected the changes in the environment and the terrestrial and aquatic ecosystems. No new species have been identified in all locations. However, some local and endemic species were identified in Feonoku River Km 335+450 (B#51), Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53), and Baikabai River Km 348+400 (B#54) where remnants of primary and

[1] *Phalanger carmelitae* is classified by IUCN as of least concern.
[2] *Dendrolagus goodfellowi* is classified by IUCN as endangered.
[3] *A. stephaniae* is listed by IUCN as least concern and is an endemic species.

[4] *Nothofagus grandis* is listed on the IUCN Red list as least concern.

secondary forests and vegetation are evident, while Clean Water River Bridge Km 77+800 (B#4) and GorambamPam River Bridge Km 113+000 (B#6) are more natural than other locations.

IV. CONCLUSION AND RECOMMENDATION

This survey indicates that while there is generally evidence of human impact on all locations that have modified the environments in many ways, some are more detrimental than others. There is one location (B#51) located at the bottom of a high montane sub-alpine vegetation was reported to have one endemic mammal (Phalanger carmelitae that is considered of the least concern (IUCN). Three specific locations (B#52, B#53, and B#54) that still have remnants of montane forests beside or near the Highway were reported to have two endemic mammals (Phalanger carmelitae and Dendrolagus goodfellowi) and one bird (Astrapia stephaniae). In addition, locations B#52, B#53, and B#54 also have sightings of Nothofagus grandis, an endemic species of Beech tree. According to the IUCN Red list, Dendrolagus goodfellowi is considered endangered, while the other two species are listed as of the least concern. Korthalsia zippelii recorded in B#4, is widely spread in the tropical lowlands and is not threatened. Octomeles sumatrana, a commercially important tree species located at B#7, is not a common grassland flora. Humans may introduce its presence at this location. Similarly, Nothofagus grandis located in B#30, is of least concern according to IUCN. Its appearance at this location may be through humans.

No unique or threatened aquatic fauna were noted. All species were either introduced or commonly available. Similarly, the only aquatic flora recorded is green algae.

The general absence of terrestrial mammals, reptiles, and frogs may be attributed to the timing of the survey, the weather, and climatic conditions. For instance, Markham Plains was experiencing a dry season at the time of the survey, which may have caused the terrestrial fauna to go into hiding. A similar condition also existed on the Eastern Highlands side of the Highlands Highway, where the absence of other terrestrial fauna was also noted. On the other hand, the aquatic fauna was consistently recorded except where the river or creeks were dried up.

The existence of quarries also affects the vegetation and the general environment of the locations, thus modifying them.

REFERENCES

[1] Allen, G. R. (1991). Field Guide to Freshwater Fishes of New Guinea. Christensen Research Institute, Madang Papua New Guinea
[2] Barford, A.S., Bamka, R. & Dowe, J.L. (2001). Field Guide to Palms of Papua New Guinea – with multi-access key and notes on the genera. Aarhus University Press, Denmark.
[3] Henty, E. E. (1981). Handbooks of the Flora of Papua New Guinea Volume 2. Australia, Melbourne University Press.
[4] IUCN Red List (2019). https://iucnredlist.org/
[5] McGavin, G. C. (2000). Insects, Spiders, and other Terrestrial Arthropods. London, Dorling Kindersley
[6] Morrison, John Lamoreaux, et al (2000). Terrestrial Ecoregions of the Indo-Pacific: A Conservation Assessment. Washington, DC: Island Press, 2000. 643 pp. ISBN 1-55963-923-7
[7] Parsons, M. (1983). Papua New Guinea Butterflies. Papua New Guinea, Insect farming & Trading Agency Productions.
[8] Womersley, J. S. (1978). Handbooks of the Flora of Papua New Guinea Volume 1. Australia, Melbourne University Press.
[9] WWF (2006). Assessing the management effectiveness of Papua New Guinea's protected areas using WWF's RAPPAM methodology.
[10] WWF (2021). PNG Protected Area Forum.

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Challenges of MSME in Manipur Post Covid-19: A Pilot Study

Dr. Jianguanglung Dangmei[1], Prof. Amarendra Pratap Singh[2]

[1]Post-Doctoral Fellow, ICSSR, Department of Business Management, Indira Gandhi National Tribal University, Amarkantak (M.P), India
[2]Head, Department of Busness Management, Indira Gandhi National Tribal University, Amarkantak (M.P), India

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***Abstract*— *The Covid-19 epidemic had affected every economic sector, but nowhere are they affected as severely as the MSMEs in India. MSMEs realise that they must develop and change over time in order to remain competitive. The purpose of this study is to determine the extent of challenges posed by MSMEs of Manipur after COVID-19 and to make recommendations for solutions to ensure their viability during these trying times. It also aids in understanding and identifying the numerous problems these enterprises are currently experiencing. The findings in this research have significant ramifications that will enable the economy to recover from its crisis. As a result, the research intends to present data that will evaluate the MSME in this period by outlining the challenges. It was found that the biggest challenges include market competition from larger corporations, product costs, poor infrastructure, and a lack of technical expertise. The overall level of challenges faced by the MSME of Manipur is also high. The challenges that the MSME faces are essentially the same for both male and female. Therefore, MSMEs in Manipur can strengthen their position in the global market by strong emphasis on increasing exports and creating domestic demand that is necessary for the MSMEs sector to quickly recover through advancements and innovation in technology, infrastructures and products.*

***Keywords*— Covid-19, Challenges, MSMEs, Manipur.**

I. INTRODUCTION

In India, the MSME sector serves as a breeding ground for inventors and entrepreneurs who greatly contribute to enhancing the business ecosystem. Any challenges of organizations must be evaluated in order to figure out whether the business will succeed or fail in achieving their goals. One of the most crucial sectors that are impacted by COVID-19 is MSME sectors and their businesses are among the most endangered (Dubey and Sahu, 2020, Sipahi 2020). There is no doubt that now the COVID pandemic disaster has worsened the state of the economy. However, this crisis might well be converted into a chance to revitalize the MSME sector, which has been experiencing chronic slowdown over the previous few years. The repercussions are numerous and extensive, including job loss, decreased revenue creation, decreased sales, and a decrease in working-class income (Hariharan et al., 2021). In this regard, it is believed that the threat of COVID-19 that we currently feel also stresses out workers and impairs their productivity. It is impossible to overlook the importance of the MSMEs sector in expanding the Indian economy. There won't be much to look forward to for the economy unless we improve the MSME sector especially for rural development. The MSME sector has been brought to its knees by the COVID-19 lockout, which has stopped some of the businesses and dried off earnings. This study is essential for summarising the current situation and for providing information for upcoming investigations.

II. OBJECTIVES OF THE STUDY

The prime focus of this study is to examine the challenges encountered by MSMEs in Manipur following the COVID-19 pandemic. It consists of the following objectives.

1. To assess gender implications in challenges faced by MSME in Manipur.

2. To measure the level of challenges encountered by MSME in Manipur post Covid-19.
3. To identify the critical challenges of MSME in Manipur post Covid-19.
4. To explore measures for revival and sustainability of MSME in Manipur.

III. HYPOTHESIS OF THE STUDY

The hypothesis developed for the study is as follows:

a. **H_1:** There is a significant difference in challenges faced by MSME between male and female workers post Covid-19 in Manipur.

IV. REVIEW OF LITERATURE

According to Meeravali Shaik, et al. (2017), the MSME sector has positively impacted employment and growth of assets, but it continues to encounter a number of difficulties, including a lack of timely credit, excessive credit costs, trouble obtaining raw materials, issues with storage and design, poor infrastructure, outdated technology, a lack of competent labour, etc. It recommends the government to implement comprehensive strategy with effective governance for the MSME in order to support the sector's growth and productivity. By utilising the enormous and still largely underutilised natural and human resource base present in the rural countryside, Sarabu (2019) stressed the importance of MSMEs' expansion in transforming our economy in rural regions. Most of the MSMEs rely on inherited traditional skills and widespread use of local resources, MSMEs have been crucial to the economic and social growth of India (Indrakumar, 2020). Because of their size, scope of operations, and other factors, MSMEs have experienced disruptions to their regular operations that have increased their stress levels, lack of funding, a cash crisis brought on by COVID-19, logistical problems, and their incapacity to deal with the fallout from such an unplanned calamity. As a result of the COVID-19 epidemic, the MSMEs sector particularly are exposed, and this vulnerability is due in part to their size, scope of operations, lack of financial executive resources, and in particular their inability to cope with an unforeseen event (Sipahi, 2020). Also issues with the supply chain, the production process, and the unavailability of raw materials and labour, COVID-19 has a significant negative effect on the MSMEs sector and reduces revenue creation (Singh, 2020). Financial instability, a scarcity of raw materials, a lack of available labour, etc., these unusual situations led the businesses to either reduce their operations, or both or to change, as necessary, between non-essential and essential goods, such as masks, PPE kits, sanitizers, etc (Tripathy, 2020).

V. RESEARCH METHODOLOGY

This study is exploratory in nature. It is based on both primary and secondary data. A closed ended questionnaire with 5-point Likert scale ranging from 1- Strongly Disagree to 5-Strongly Agree was used to measure the challenges faced by the MSMEs. Secondary data were collected from google scholar and government websites. Primary data were collected using simple random sampling technique from workers of MSMEs through structured questionnaires which contain 10 questions. A sample size of 238 from three districts viz. Thoubal, Kakching and Churachandpur was collected of which 230 respondents were considered for the study after data cleaning. For the purpose of measuring the level of challenges, scale based on the maximum and minimum score by converting the five scales into three group scales is used as Low, Moderate and High. For analysing data, statistical tools like Excel, Cronbach Alpha and Independent Sample T – Test were used to analyse the data using SPSS 23.0 version.

VI. DATA ANALYSIS AND RESULTS

The descriptive statistics of the data collected are as given below:

Table 1: Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	138	60.0	60.0	60.0
	Female	92	40.0	40.0	100.0
	Total	230	100.0	100.0	

Table 2: Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10-25 years	18	7.8	7.8	7.8
	26-35 years	146	63.5	63.5	71.3
	36-45 years	64	27.8	27.8	99.1
	46 and above years	2	.9	.9	100.0
	Total	230	100.0	100.0	

Table 3: Qualification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10^{th}-12^{th} standard	63	27.4	27.4	27.4
	Bachelor	149	64.8	64.8	92.2
	Diploma	3	1.3	1.3	93.5
	Master	14	6.1	6.1	99.6
	No formal Education	1	.4	.4	100.0
	Total	230	100.0	100.0	

Table 4: Place of the Enterprises

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Thoubal	70	30.4	30.4	30.4
	Kakching	68	29.6	29.6	60.0
	Churachandpur	92	40.0	40.0	100.0
	Total	230	100.0	100.0	

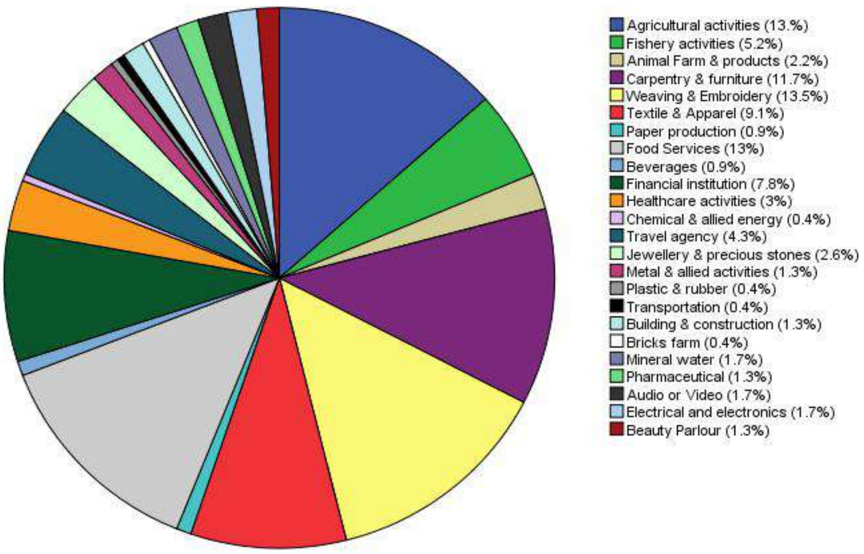

Fig. 1: Type of Enterprises

(Source: Authors)

Table 5: Statement of the Challenges

Statement	N	Mean	Std. Deviation
CC_1: Lack of raw materials and inadequate procurement.	230	3.66	1.101
CC_2: Financial resource is now more difficult to access.	230	3.88	.784
CC_3: Scarcity of trained and skilled workers.	230	3.73	.995
CC_4: Inadequate technological knowledge and operation.	230	4.04	.708
CC_5: Production costs are high.	230	4.08	.636
CC_6: Inadequate infrastructures for running business.	230	4.07	.680
CC_7: Lack of market access and low market demand.	230	3.73	1.125
CC_8: Market competition with larger corporations is tough.	230	4.08	.772
CC_9: Entrepreneurial ambitions, capacities, and know-how are lacking.	230	3.95	.740
CC_10: Lack of understanding about government schemes and programs.	230	3.69	1.035
Valid N (listwise)	230		

Table 6: Reliability Statistics

Cronbach's Alpha	N of Items
.798	10

The items used for the study is reliable as the value of the Cronbach's Alpha is 0.798.

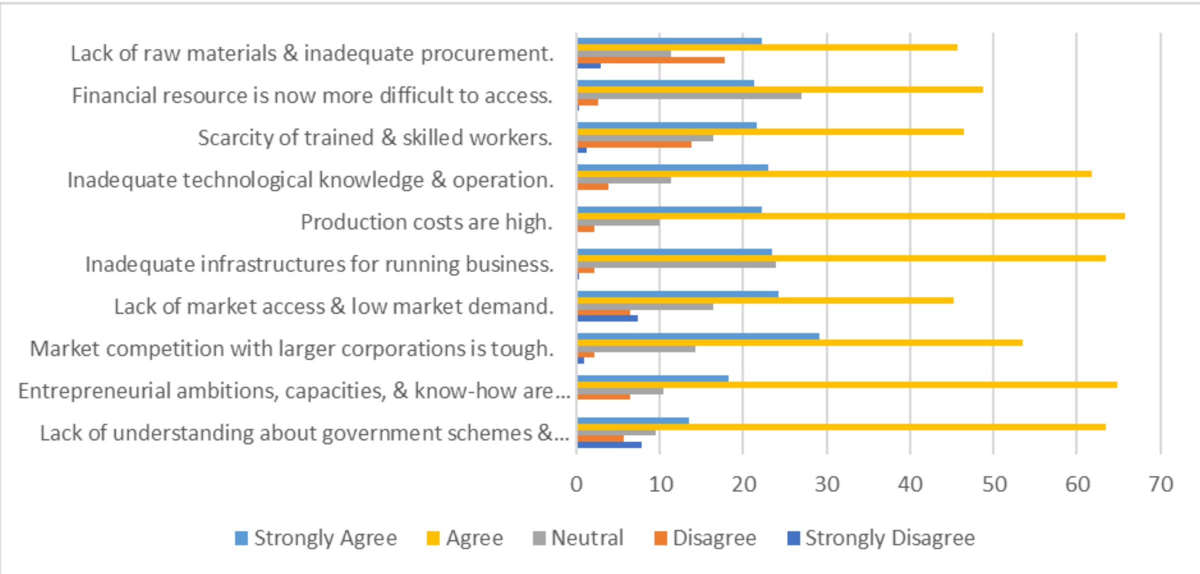

Fig. 2: Challenges of MSME in Manipur (in percent)

(Source: Authors)

From the above Fig. 2, most of the respondents agree that there are challenges faced by MSMEs in Manipur according to the statement as mentioned above. Market competition with larger corporation, product costs, inadequate infrastructure and lack of technical knowledge were the biggest challenges among them (See Table 5 and Fig.2).

Table 7: Independent Samples T-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
CHALLENGES	Equal variances assumed	.093	.761	.634	228	.527	.446	.703	-.939	1.830
	Equal variances not assumed			.628	189	.531	.446	.709	-.953	1.845

Since, the p-value obtained is above 0.05, we accept the null hypotheses. Therefore, there is no significant difference in the challenges faced by the MSMEs in Manipur between male and female workers.

Table 8: Level of Challenges

Scale	**Level**
1.00 to 2.33	Low
2.34 to 3.67	Moderate
3.68 to 5.00	High

The obtained score for the level of challenges is 3.89 which falls in the high level of the scale. Therefore, the level of challenges faced by the MSMEs in Manipur is quite high.

VII. CONCLUSIONS AND IMPLICATIONS

Following an assessment of the challenges faced by MSMEs in Manipur, it was concluded that the biggest challenges include market competition from larger corporations, product costs, poor infrastructure, and a lack of technical expertise. The overall level of challenges faced by the MSME of Manipur is also quite high. Adoption of practicable policies, such as stable prices, should be made to facilitate marketing access and primarily e-market linkages in the existing market. Infrastructure should be also established to support technical advancement and diversification. Since it is challenging for MSMEs to thrive in this period of fierce competition, they should seize this chance to focus more on innovation and increase their working capital limits. Through advancements in technology and strategies, MSMEs in Manipur can strengthen their position in the global market. A strong emphasis on increasing exports and creating domestic demand will be necessary for the MSMEs sector to quickly recover. The pandemic also presents a chance to reckon, reorganise, and revive business paradigms.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

[1] Dubey P. & Sahu K.K. (2020). MSMEs in COVID-19 crisis and India's economic relief package: a critical review. *International Journal of Indian Psychology*, *8*(4), 1651-1656. DIP:18.01.179/20200804, DOI:10.25215/0804.179 [Google Scholar]

[2] Hariharan, A., Thomas, S., & Viswanathan, P. K. (2021). Impact of COVID-19 on the performance of micro, small and medium enterprises (MSMEs) in India–A case study in Kerala. *Annals of the Romanian Society for Cell Biology*, 14797-14816. [Google Scholar]

[3] Indrakumar, D. (2020). COVID-19 and its impact on Micro, Small and Medium Enterprises in India. *Manpower Journal*, *54*(3&4), 75-88. [Google Scholar]

[4] Sarabu Vijay. Role of Micro, Small & Medium Enterprises (MSMEs) in the Rural Development of India- A Way Forward, 2019. https://www.researchgate.net/publication/336891538_Role_of_Micro_Small_Medium_Enterprises_MSMEs_in_the_Rural_Development_of_India_A_Way_Forward

[5] Shaik, M., Ramesh, K. V., Kumar, K. A., & Babu, G. S. (2017). Performance of MSMEs sector in India. *SSRG International Journal of Economics and Management Studies (SSRG-IJEMS)*, *4*(3), 11-15. [Google Scholar]
[6] Singh, A. (June 12, 2020). What about India's MSME Sector: COVID-19 pandemic and Indian MSMEs sector outlook. Available at SSRN: https://ssrn.com/abstract=3696778 or http://dx.doi.org/10.2139/ssrn.3696778
[7] Sipahi, E. (2020). COVID 19 and MSMEs: A revival framework. *Research Journal in Advanced Humanities*, *1*(2), 7-21. [Google Scholar]
[8] Tripathy, A. (2020). COVID-19 affect and micro, small, and medium enterprises (p. 5). The Times of India. https://timesofindia.indiatimes.com/blogs/agyeya/covid-19-affect-on-micro-small-and-medium-enterprises-msmes/

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Analysis of CPUE and Fishing Capacity of demersal fisheries in Kema 2, North Sulawesi, Indonesia

Alfret Luasunaung[1]*, Mariane M. Kayadoe[1], Frangky E. Kaparang[2], Marvin Lestaluhu[2]

[1]Faculty of Fisheries and Marine Science, Sam Ratulangi University, Indonesia
[2]Student of utilization fishery resourches study program, Sam Ratulangi University, Indonesia
*Corresponding Author

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Abstract— *Capture fisheries should be a sustainable economic activity aspect to provide good benefits to future resources. Sustainable marine fisheries resources exploitation requires a utilization rate lower than their availability. Therefore, the exploitation rate should not achieve the recovery ability of the resources in certain time. In fishing activities, for instance, there is a guideline not to catch fish over the Total Allowable Catch (TAC), 80% of the MSY. Information on the potency and the fishing capacity of tuna fisheries can be useful for the sustainable management of the resources. Also, this information can be used as a consideration for further management of the potency.*

There are two purposes of the study: (1) to analyze the CPUE (catch per unit effort) of demersal fisheries in Kema 2, North Sulawesi, for prediction of their potency, and (2) to analyze the efficiency of fishing capacity of the demersal fisheries in Kema 2, The study was done in two stages. The first was done by analyzing the potency using CPUE method (Shaefer models) to obtain the MSY, optimum effort and TAC (total allowable catch); and the second was done by analyzing the fishing capacity of demersal fisheries using DEA method to estimate the efficiency level of the fishing boats and devices in Kema 2.

The result showed that the potency of demersal fisheries in Kema 2 was 71,700 tons per year and the optimum effort was 72,964 trips. Fishing capacity in demersal fisheries occurred in Kema 2 for the last 12 years was inefficient, especially for 2001. This may be caused by some factors such as trip operation, fishing duration, oil consumption, crew and operational cost. So, to manage the demersal resources in Kema 2, the TAC should be 57,520 tons per year. Based on the result, to increase the fishing efficiency, we should take into account of above factors. We suppose that the good means is reducing trip operation, fishing duration, oil consumption, crew and operational cost.

Keywords— ***CPUE, MSY, TAC, Fishing Capacity, Kema 2***

I. INTRODUCTION

Capture fisheries is an economic activity that has high contributions to the production of marine fisheries in North Sulawesi Province. Kema 2 is a part of North Sulawesi Province geographically located at N 1°23'23" - 1°35'39" and E 125°1'43" - 125°18'13".

Demersal fish is one of the fisheries commodities in Kem 2 having economic value. It can be exported as fresh fish several countries. Since demersal fish has become an export commodity, fishing activities of the local fishermen is increasing. Nevertheless, there is no information on the potency of demersal resources.

Control on fishing effort is one of the approaches to manage the fisheries resources relating to restrictions on the fishing capacity or the amount of fishing gears. The goal is to increase catches and fishing industry's economic performances through reduced effort or excessive fishing capacity. The issue of managing fishing capacity has developed along with the developing attention to the phenomenon of the excess spread in fishing inputs and overcapitalization in world fisheries (Loftas 2001; Yu and Yu 2007).

II. RESEARCH METHOD

a. CPUE Analysis

Catch estimates could be used to illustrate a fsiheries development using Catch Per Unit Effort method. This study employed a production model to estimate demersal stocks in Kema 2 the relationship between the catch (C) and fishing effort (f). The assumption underlying this relationship is the catch per unit effort (CPUE) with a mathematical model of Gulland (1983):

C/f = a bf……………………………………………… (1)

C = af-bf2 …………………………………………… (2)

Optimum effort (fopt) can be obtained by following equation :

fopt (Effort MSY) = -a/2b ………………………… .(3)

by substitution equation (3) into equation (2) will be obtained the maximum sustainable catches (CMSY),

CMSY = -a2/4b ……………………………………… (4)

FOpt (EffortMSY) = -0.5 x a/b ……….……………… (5)

b. Fishing capacity analysis

Data Envelopment Analysis (DEA) was be used to calculate the fishing capacity with the approach (Fare, et al.,1989, 2000; Gréboval, 2003).). Data Envelopment Analysis is a mathematical analysis program for estimating the technical efficiency of production activities simultaneously. The analysis uses panel data model with multi-input and single output. In fisheries applications, DEA has advantages in terms of its ability to estimate the capacity under the implementation constraints of certain policies, such as the Total Allowable Catch (TAC), taxes, regional distribution or vessel size, catch restrictions at certain times (when the pollution, for example), and those of other socio-economic development.

The unit of observation is fishing boat and input and output data based on yearly trips of boat (input) and its caught (output). DEA approach used in this study was the minimization of inputs (input oriented) and the maximization of output (output oriented). This approach is used to measure how many outputs are produced by a number of fishing vessels without any reductions and how many inputs (effort) should be induced to have stable amount of output (catch). To estimate the technical efficiency of fishing effort over the last 12 years 1999-2010 (long term) using input minimization approach with the assumption that there J effort (trip), where j = 1, 2, ... J; j =12) as an input with an output from the catch by using a model assuming constant returns to scale (CRS) with the formula (Kirkley and Squires 1999):

$$TE = Max\ \theta$$

$$\theta u_j \le \sum_{j=1}^{J} z_j u_j \qquad \text{……………………………(6)}$$

$$\sum_{j=1}^{J} z_j x_{jn} \le x_{jn}, n \in \alpha$$

$$\sum_{j=1}^{J} z_j = 1$$

$$\sum_{j=1}^{J} z_j x_{jn} = \lambda_j x_{jn},\ n \in \hat{\alpha}$$

$$z_j \ge 0, \lambda_{jn} \ge 0 \,\forall\, n \in \hat{\alpha}$$

where j = 1,2, ..., J is the year of observation as decision making units. Thus there are 12 years of observation or J = 12 and n = 1,2, .., n inputs (n = 1).

Description: TE, technical efficiency for years to j; , the measurement value for each observation (1); UJ, output for the year-to-j is an output (catch); xjn, the n-th input is used, consisting of a fixed input (the amount of effort each fishing gear); j, the level of use of the n-th input variable; ZJ, intensity of use of variables.

III. RESULT AND DISCUSSION

a) Analysis of CPUE

Catch per unit effort (CPUE) is a ratio commonly used to eliminate temporal and regional trends in fish stock abundance. The "catch" portion of the measure may be expressed as the number or weight of the entire catch, a selected subset of the catch, or a particular species in the catch. The "effort unit" portion of the rate usually refers to the time a uniformly designed and employed piece of fishing gear is deployed in the water. In the absence of uniform gear use, CPUE could be applied as a coarser scale utilizing whatever effort data is available.

Table 1. Demersal fish catches (tonnes) and effort (trips) during the period of 12 years

Year	Catch	Effort	CPUE
	(ton)	(trip)	(ton/trip)
1999	56626.29	42660	1.327386076
2000	56330.51	37200	1.514260887
2001	56561.36	31500	1.795598571
2002	51667.07	30160	1.713098972
2003	52481.57	34940	1.502048226
2004	59489.15	48000	1.239357188
2005	59869.08	50185	1.19296762
2006	59327.46	52240	1.135671133
2007	60459.08	53600	1.12798041
2008	63721.62	60230	1.057971443
2009	60233.98	90580	0.664981011
2010	68236.79	116840	0.584019043
Total	705004.60	648135	14.85534058
Mean	58750.38	54011.25	1.237945048

Intercept (a) = 1.96536983

Slope (b) =-0.0000135

CMSY = -a2/4b = 71700.918 ton

FOpt. = -a/2b = 72964.301 trip

TAC = 0.8 * MSY = 57360.734 ton/year

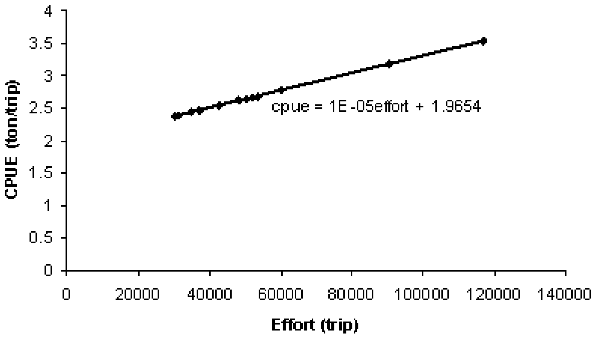


Fig.1. Relationship between effort (trip) and CPUE (tons/trip)

Figure 1 shows that there is a tendency of increased effort (trip) will increase the catch per unit effort as well (tons / trip). The analysis above shows that CMSY occur at 71700.918 tonnes while the optimum effort occurred at 72964.301 trip. Total Allowable Catch (TAC) demersal fish in Kema 2 is suggested to run 57360,734 tons / year so that these resources remain intact

b) Fishing Capacity Analysis

The analysis was based on the period of 1999 to 2010 for efficiency comparison between gear types and input approaches that are constant returns to scale (CRS) and analysis of the efficiency of the same type of fishing gear with the output approach which is variable returns to scale (VRS).

(1) Assessment of long-term efficiency (over time) Measurement of fishing capacity can be done in the long term and short term. DEA method for long term used time series data and a decision making unit (DMU) is year. The output variable is the actual catch, while the input variable is mean effort (trip) per year. The results will provide information on the status of the inputs used to achieve the absolute efficiency.

Demersal fishing activities around Kema 2 in the last 12 years fluctuated in terms of efficiency. Since 1999-2001 there was a trend for levels of efficiency and in subsequent years (2002-2010) showing a pattern of decreasing in the level of inefficiency. In 2001 the fishing activity had an efficiency value of 1 meaning that the effort spent was in accordance with the catches obtained. The fluctuation in the level of annual efficiency of demersal fisheries in Kema 2 is presented in Figure 2.

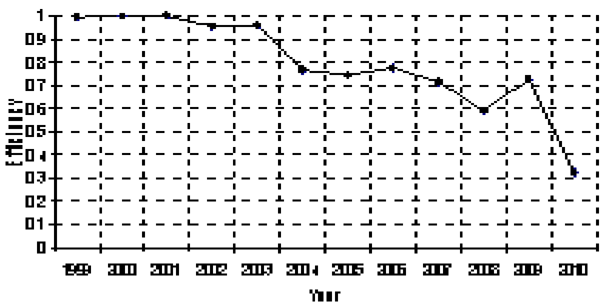


Fig.2. The efficiency of demersal fisheries in Kema 2

Figure 2 illustrates that within the last 12 years the efficiency value of the demersal fisheries in Kema 2 from year to year tends to decrease. The highest efficiency level (has a value equal to 1) occurred in 2001. The relative efficiency of demersal fisheries can be used to determine the exploitation condition of demersal fish in the waters of Kema 2 by multiplying the actual efforts used and the relative efficiency in order to obtain the target capacity (Table 2 and Figure 3).

Table 2. Efficiency score, actual effort, targeted effort and excess in capacity of demersal fisheries in Kema 2

Year	Score	Actual	Target	Excess in Capacity	
	Effici-ency	Effort	Effort	Trip	%
1999	0.993	42660	42361.38	-298.62	0.16
2000	0.998	37200	37125.60	-74.40	0.04
2001	1.000	31500	31500.00	0.00	0.00
2002	0.954	30160	28772.64	-1387.36	0.76
2003	0.962	34940	33612.28	-1327.72	0.73
2004	0.766	48000	36768.00	-11232.00	6.15
2005	0.745	50185	37387.83	-12797.18	7.01
2006	0.776	52240	40538.24	-11701.76	6.41
2007	0.714	53600	38270.40	-15329.60	8.40
2008	0.589	60230	35475.47	-24754.53	13.56
2009	0.726	90580	65761.08	-24818.92	13.59
2010	0.325	116840	37973.00	-78867.00	43.19

In the last seven years (2004-2010), an increase in the number of efforts was sufficiently large in that the capacity increased significantly. Excess input of the largest fishing effort occurred in 2010 which reached 43.19%. The excess of actual effort against target effort is presented in Figure 3.

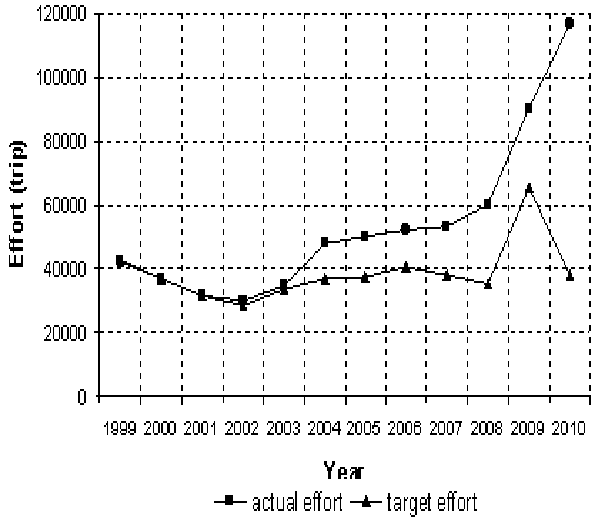


Fig.3 Comparison of actual effort and target effort of demersal fisheries in Kema 2

Figure 3 shows the difference between actual effort and target effort since 2004 to 2010 increase indicating that there was an excess in the capacity of demersal fisheries in Kema 2. It could also be seen that the difference between the target effort and actual effort is negative. Excess in number of trips could cause high pressure on the resources which could interfere with the recruitment process. If the number of actual efforts equals to the target effort then there will be 100% efficiency. Year 2001 is the year in which the amount of actual efforts equals to target efforts or the value of efficiency equals to 1, so the number of trips could be used as a reference to determining the policies for the following years.

Nine demersal fishing boats were tested for their efficiency. The results are presented in Figure 4.

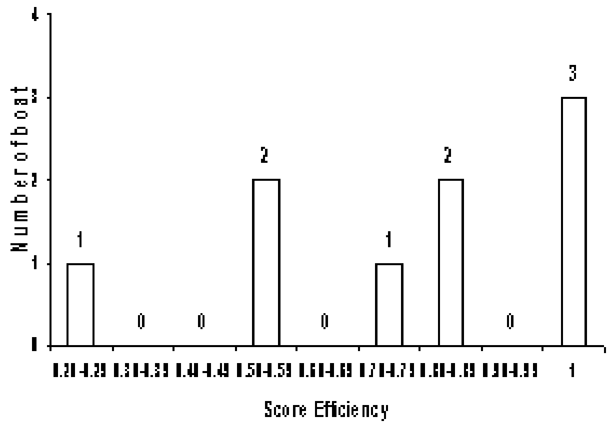


Fig.4 The efficiency of demersal fishing boat in Kema 2

Figure 4 shows that among those nine demersal fishing boats tested, only three boats have an efficiency of 1. Subsequent analysis focused only on the other six boats.

(2) Sort-term efficiency (inter-boat) assessment

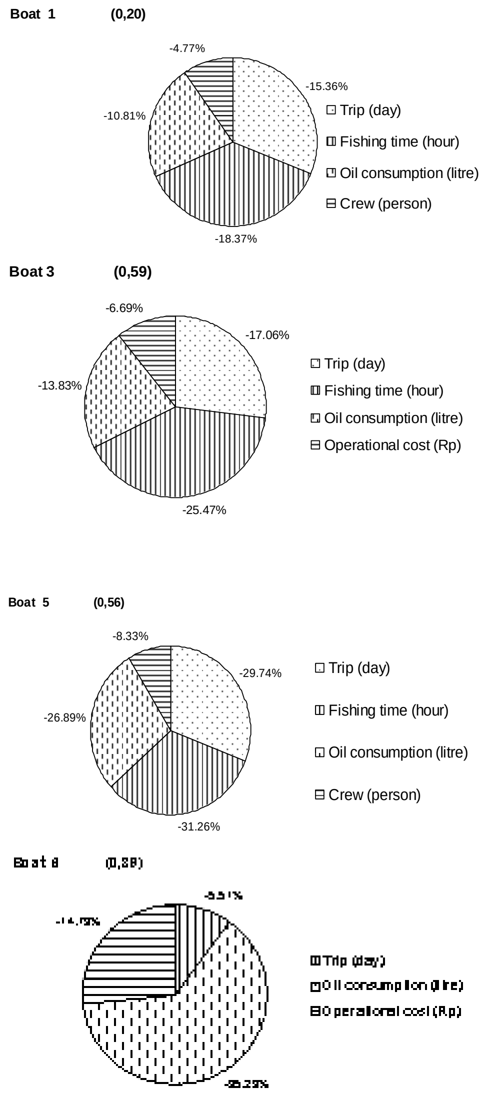
DEA efficiency analysis, in addition to long-term with the variable year as a DMU, this study also measured the efficiency of short-term nature. The analysis of a short-term efficiency was carried out by comparing the efficiency of each boat, the DMU of the tuna fishing boat itself. Input variables were trip (day), fishing time (hour), oil consumption (liter), crew (person) and operational cost (Rp). While the output variable used was demersal fish catch per boat.

Demersal fishing boat can increase the efficiency by making changes in the input variables used. The input variable adjustment is given in the Table 3 and Figure 5 below.

Table 3. Examples of demersal fishing vessels that need to be adjustment to improve efficiency

Boat		**Input**		**Deviation**	**Percentage**
1	**0,20**	**Actual**	**Target**		
Production (kg)		108			
Value of production (Rp)		1184500			
Trip (day)		27	22.85	-4.15	-15.36
Fishing time (hour)		7	5.71	-1.29	-18.37
Oil consumption (liter)		1430	1275.46	-154.54	-10.81
Crew (person)		3	2.86	-0.14	-4.77
Operational cost (Rp)		9745000	9745000	0	
3	**0,59**				
Production (kg)		250			
Value of production (Rp)		5207000			
Trip (day)		21	17.42	-3.58	-17.06
Fishing time (hour)		6	4.47	-1.53	-25.47
Oil consumption (liter)		1125	969.43	-155.57	-13.83
Crew (person)		2	2	0	0.00
Operational cost (Rp)		7688000	7173640	-514360	-6.69
5	**0,56**				
Production (kg)		326			
Value of production (Rp)		7422500			
Trip (day)		31	21.78	-9.22	-29.74
Fishing time (hour)		8	5.49	-2.51	-31.26
Oil consumption (liter)		1359	993.50	-365.50	-26.89
Crew (person)		3	2.75	-0.25	-8.33
Operational cost (Rp)		8067500	8067500	0	0.00
6	**0,89**				
Production (kg)		606			
Value of production (Rp)		12241000			
Trip (day)		25	23.62	-1.38	-5.51
Fishing time (hour)		6	6	0	0.00
Oil consumption (litre)		1435	929.52	-505.48	-35.23
Crew (person)		3	3	0	0.00
Operational cost (Rp)		9314000	7936489	-1377511	-14.79
7	**0,87**				
Production (kg)		852			
Value of production (Rp)		23597500			
Trip (day)		35	31.19	-3.81	-10.88

Fishing time (hour)	9	7.98	-1.02	-11.27
Oil consumption (liter)	965	965	0	0.00
Crew (person)	4	3.99	-0.01	-0.18
Operational cost (Rp)	9148500	9038182	-110318	-1.21
9 **0,74**				
Production (kg)	515			
Value of production (Rp)	7350000			
Trip (day)	35	27.189	-7.811	-22.32
Fishing time (hour)	9	6.849	-2.151	-23.90
Oil consumption (liter)	1326	1307.774	-18.226	-1.37
Crew (person)	4	3.424	-0.576	-14.40
Operational cost (Rp)	10441940	10441940	0	0.00



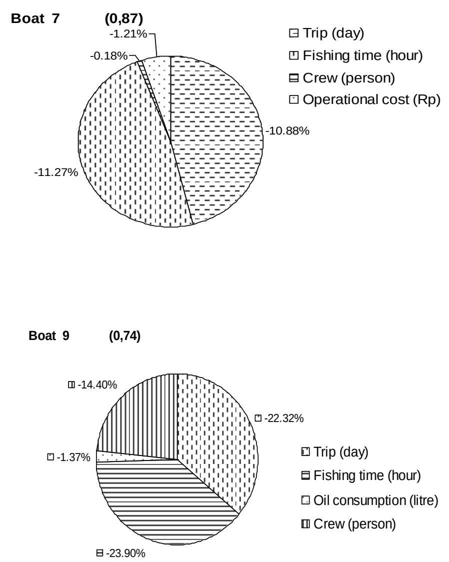


Fig.5. The potential for efficiency improvement each fishing boat

Based on Table 3 and Figure 5 shows that to improve the efficiency of demersal fishing vessels in Kema 2 the necessary arrangements in terms of fuel usage, trip operation, the number of crew, the time of arrest and operational costs as needed in each of the different ships.

IV. CONCLUSION

1. Potential demersal fisheries in Kema2 based on CPUE analysis was 71,700 tons per year and optimum effort was 72,964 trips, with a total allowable catch (TAC) of 57520 tons per year.

2. Fishing capacity for demersal fisheries along 12 last year was inefficient, especially in 2001. This may be

caused by some factors, such as fishing duration, trip operation, oil consumption, crew and operational cost. Based on the results, to increase the efficiency of fishing capacity we should take into account of these factors. The good means is by reducing fishing duration, trip operation, oil consumption, crew and operational cost.

REFERENCES

[1] Färe R, Grosskopf S, Kirkley JE, Squires D. 2000. *Data Envelopment Analysis (DEA) : A Framework for Assessing Capacity in Fisheries when Data are Limited*, Presented at the International Institute of Fisheries Conference IIFET X. Juli. 2000.

[2] Fauzi A dan Anna S. 2005. *Data Envelopment Analysis (DEA) Kapasitas Perikanan di Perairan Pesisir Jakarta* : *Pemodelan Sumber Daya Perikanan dan Kelautan untuk Analisis Kebijakan*. PT Gramedia Pusaka Utama. Jakarta. Hal : 209-233.

[3] Gréboval D. 2003. *The Measurement And Monitoring Of Fishing Capacity: Introduction And Major Considerations*. FAO fisheries technical paper No. 445. Rome p:1-24

[4] Gulland JA. 1983. *Fish Stock Assessment, A Manual of Basic Methods*. FAO/Wiley Series on Food and Agriculture, Vol. 1, John Wiley and Sons, Chichester. 223 p.

[5] Kirkley J, Squires D. 1998. *Measuring Capacity And Capacity Utilization In Fisheries. Background Paper Prepared For FAO Technical Working Group On The Management Of Fishing Capacity*. La Jolla. USA. 15-18 April 1998. 160 pp.

[6] Kirkley J, Squires D. 1999. *Capacity and Capacity Utilization in Fishing Industries* : Discussion paper 99-16 University of California, Departement of Economics. San Diego. 34 p.

[7] Loftas T. 2001. *Controlling Fishing Capacity*. http://www.oceansatlas.c.lling.html

[8] Yu H, Yu Y. 2007. *Fishing Capacity Management in China* : *Theoritic and Practical Perspectives*. Marine Policy. Journal of Ocean University of China Vol. 6 (1). p: 1-9.

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Effect of discs harrow use on lixisol roughness and clods sizes in Burkina Faso

Barro Albert[1], Sanon Florentin[1], Palé Siébou[3], Coulibaly Kalifa[2], Dayo Mamadou[1], Kientega Maurice[1], Nacro Hassan Bismarck[2]

[1]INERA (Institute for the Environment and Agricultural Researches), DRREA du Centre, BP 10 Koudougou, Burkina Faso.
[2]IDR (Institute for Rural Development), Nazi Boni University, Bobo-Dioulasso, Burkina Faso;
[3]INERA (Institute of Environment and Agricultural Researches), 04 BP 8645 Ouagadougou 04, Burkina Faso.

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***Abstract*— *Soil tillage allows a good establishment of crops in Burkina Faso. The aim of the study conducted in Saria is evaluation of the disc harrow used for tillage in order to find ways of mitigating these negative effects. The discs harrow evaluation is done at three speeds on a lixisol in Saria. The operation is carried out at two moisture levels, 9 and 12%. Measurements are made on labor time, tillage depth and width, surface roughness and clod sizes. The results indicate that labor time per hectare decreases with speed. Between 2.2 and 10.4 km.h^{-1}, the time goes from 4.00 h.ha^{-1} to 1.25 h.ha^{-1}. Under these conditions, the soil surface roughness index varies from 1.27 at low speed to 1.06 for high speed. The size of clods increases from 1550 cm^3 2.2 km.h^{-1} to 81 cm^3 for 10.4 km.h^{-1}. The reduction of the clods sizes makes the plots sensitive to runoff and soil erosion. Soil tillage at an average speed of 6 to 7 km.h^{-1} maintain the roughness and the clods sizes and makes it possible to achieve a time of 1.6 h.ha^{-1}. The traction force is 315 DaN for 7 cm deep and 210 cm wide. It is possible to reduce labor time by increasing the tillage width and maintaining a speed of 6 km.h^{-1}.*

***Keywords*— Clod sizes, labor time, roughness, speed, tillage.**

I. INTRODUCTION

In the Sahel, the issue of environmental preservation involves integrated soil management. The resolution of the challenge of food and nutritional security in Burkina Faso must be done with a sustainable production system for the benefit of the populations [1]. In order to increase cereal production, producers are increasingly using the disc harrow for tillage [2]. This tool is used in more than 80% of farms in the western cotton zone of the country. It is appreciated by these users because of its speed and its earliness in carrying out the tillage. Indeed, for a soil wetting depth of 10 cm as for scarification with a manga hoe, the tillage operation with a disc harrow can begin well before plowing [3]. The use of this tool despite these advantages can lead to significant water erosion in poor conditions of use. Recommended speeds vary from 5 to 7 km.h^{-1}for ride-on discs harrow [4, 5]. The speed varies according to the soil conditions (physical state of the soil, quantity of organic matter to be buried, quality of the grinding of the organic matter, first or second pass, presence of stones or roots, etc.). In the climatic conditions of Burkina Faso where the rains are of high intensity especially at the beginning of the season, the soil surface state has an important role on runoff and erosion [6, 7, 8].

This study is intended to evaluate the effect of tillage speed with the disc harrow on the soil surface condition at the Saria research station.

II. MATERIAL AND METHOD

2.1 Study site

The study was carried out in Burkina Faso at the Saria station (12° 16' N and 2° 9' W), located at 80 km west of Ouagadougou. The climate is north-Sudanian type [9]. It includes a dry season of 7 months (November – May) and a rainy season which lasts 5 months (June-October). The annual average rainfall is 800 mm. The rains are irregular in space and time, inducing periods of drought that are very often harmful to crops. Crops are planted at the start of the rainy season during the period of high evaporation with 5 mm per day of potential evapotranspiration (ETP) [10].

The vegetation is wooded savanna type, with the main woody species: *Khaya senegalensis, Annogeissus leiocarpus*, *Acacia penata*, *Mitragyna inermis*, *Tamarindus indica*, *Ficus sp.*, *Accacia ssp.*, *Combretum ssp.*, *Vitellaria paradoxa, Guiera senegalensis, Boscia senegalensis, Zizyphus mauritiana and Piliostigma ssp*. The herbaceous cover is composed by *Pennisetum pedicellatum, Schoenfeldia gracilis, Loudecia togoensis* and *Andropogon Sp*. [9].

The soil is leached lixisol type [11], with an average depth varying from 80 to 100 cm. This depth is limited by the presence of petroplinthite layers [3, 12]. The slopes are on average low (≤ 1%), but the rains are often high intensity (50 to 80 mm.h^{-1}). The texture of the tilled horizon is sandy-clayey (on average 55% sand, 31% silt and 14% clay). The soils are poor in organic matter (< 1% on average), in nitrogen (≈ 0.7 g.kg^{-1}) and in assimilable phosphorus (≈15 mg.kg^{-1}). Their water storage capacity (WRC) is low (80 to 100 mm.m^{-1}) [13, 8].

2.2 Tillage equipment

Tillage was carried out by the 16 discs harrow tool. Eight are crenelated at the front and 8 other normal at the back. The disc diameter is 50 cm. The tillage width is 210 cm.

The Mahindra model 605 DI two wheels drive tractor has been used. It has a power of 57.00 CV or 42.50 kW.

Fig. 1: Discs harrow hitched to the Mahindra 605 DI tractor during experiments.

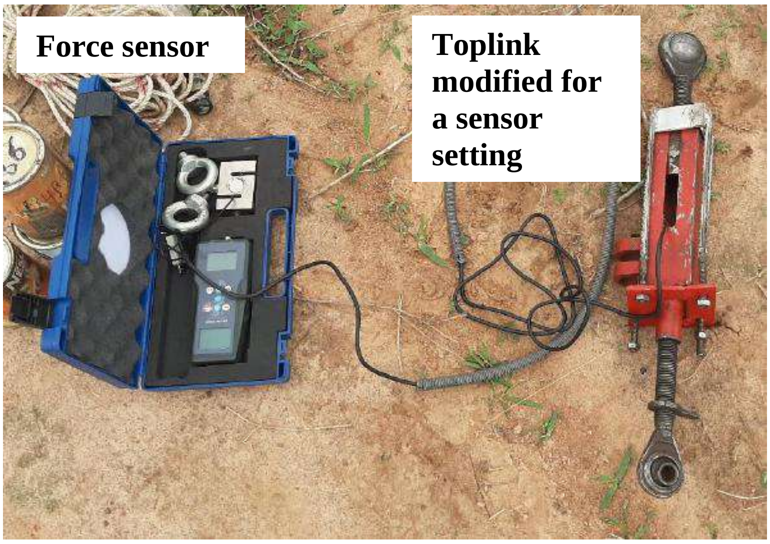

Fig. 2: MF 207 1000 kg traction and compression dynamometer on third point arm modified for insertion of the force sensor.

2.3 Experimental Design

The study device has three main plots of 51.0 x 15.8 m. On plot P1, tillage with the disc harrow was done at a speed of 2.19 and 3.82 km.h^{-1}. On plot P2, it was carried out with the same tool at a speed of 5.13 and 5.67 km.h^{-1} , and on plot P3 at a speed of 10.40 and 9.81 km.h^{-1}. The average tillage depth was measured as well as the tillage width.

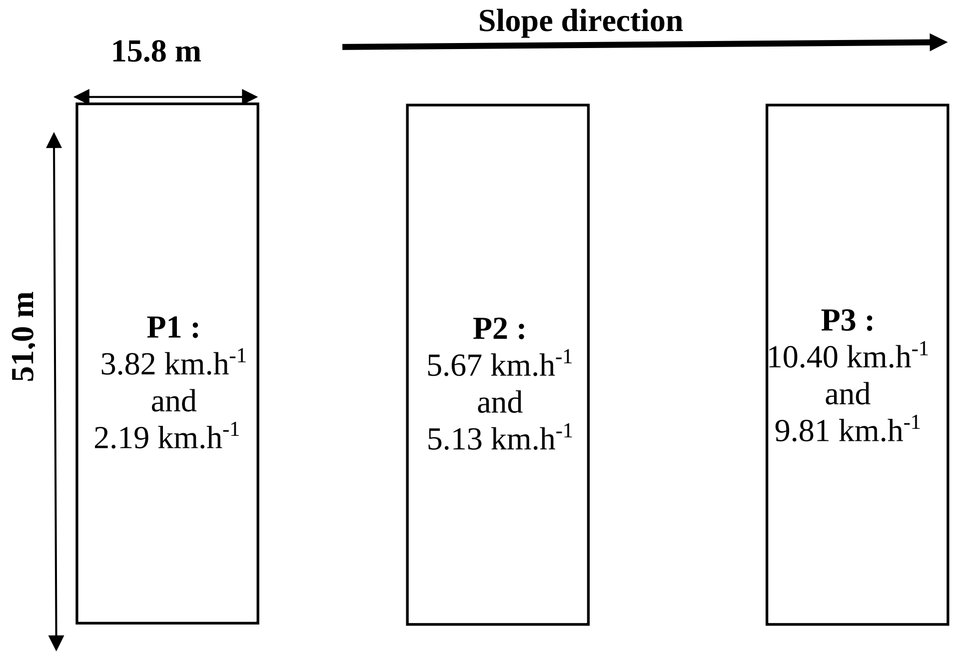

Fig. 3: Experimental device

2.4 Measurements and observations

- The sizes of the clods have been measured in 1 m² surface in 4 repetitions on each plot. The longest side is the length, the next side is the width, and the shortest side is the thickness.

- The labor time has been measured. Tractive force was measured by placing a traction and compression dynamometer on the tractor's TopLink modify (Fig. 2).

- The soil roughness was measured by the chain method [14]. The chain, 1.0 m long (L) is placed on the surface of the soil so that it hugs the surface micro-modeling. The vertical projection of the chain (lo) is then measured with a tape measure (10 repetitions).

2.5 Data processing

The data is processed by the XLSTAT Version 2021 2.2.1141 software. The variance analysis module is used and the comparison of means is made by Newman-Keuls test. The regression module has also been used.

III. RESULTS

3.1 Traction force and tillage depth

The traction force average is 314.7 daN. The standard deviation is 157 daN (Table 1). The presence of stumps on the plot caused peaks reaching of 550 daN.

The analysis of variance carried out on the tillage depth indicated its slight decrease when the speed of the tool increases (Fig. 1). The probability is 0.042. Speeds of 2.19 and 5.13 km.h^{-1} have an average depth from 7.0 to 6.6 cm. The depth of the greatest speed has been 6 cm on average.

Table 1: "V" Disc Harrow Traction Force

Parameters	Traction Force (daN)
Mean	314.7
Standard error	157.1

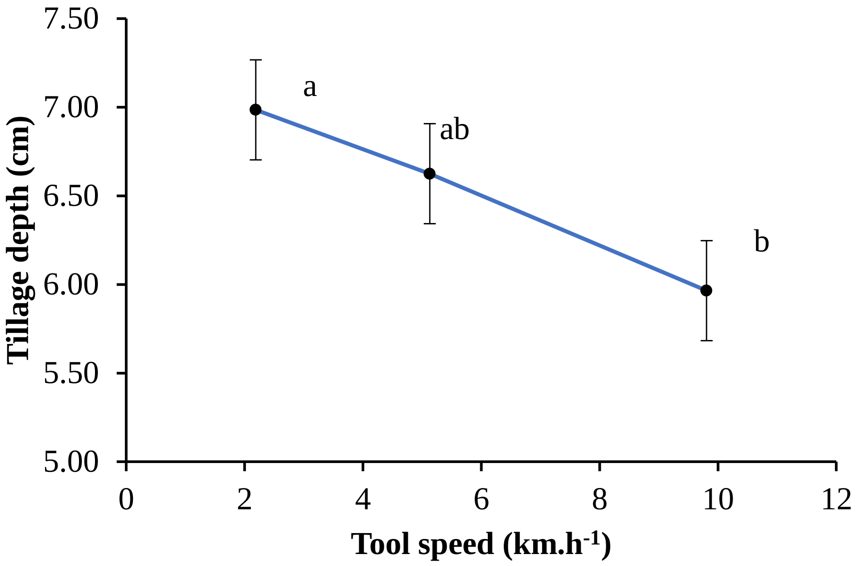

Fig. 4: Variation of tillage depth according to the tool speed

Note: a, ab and b denote different groups of means

3.2 Labor time

The variation in labor time per hectare is shown in Fig. 5. The labor time reduction was a function of the speed (Fig. 5). With n=6 the coefficient of determination of 0.97 is very highly significant.

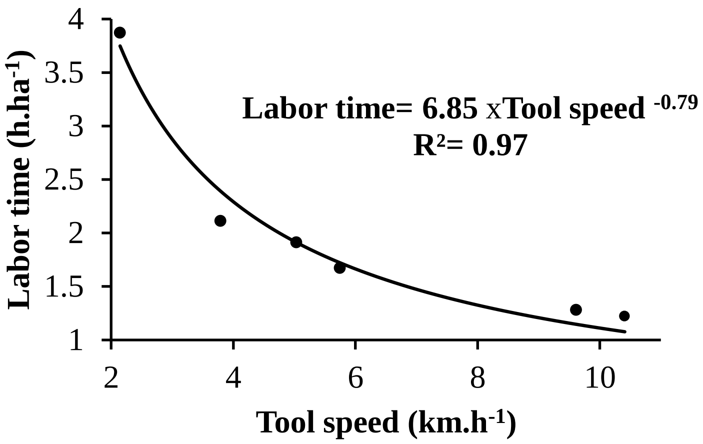

Fig. 5: Variation of labor time per hectare according the tool speed

3.3 Soil roughness index

The graphs in Fig. 6 below show the variation of the soil surface roughness index in two tillage conditions (at 9 and 12% moisture). In both situations the analysis of variance shown a very highly significant difference between the means of the roughness index on the three plots. The probability is less than 0.0001. At the high speed of passage around 10 $km.h^{-1}$, the roughness index is close to that of the initial state of the soil before the tillage. The analysis of the roughness after a rain of 8.5 mm shown a very highly significant difference between the roughness index on the plot at high speed (10 $km.h^{-1}$) and the two other plots. On the plot treated at 10 $km.h^{-1}$ there is no index reduction after this rain.

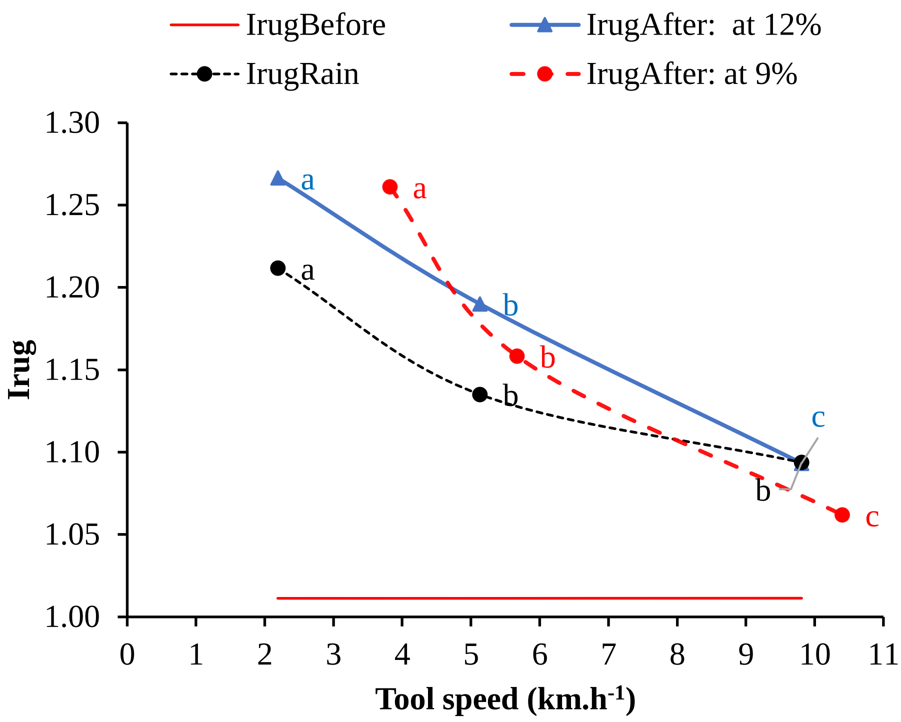

Fig. 6: Variation of the roughness index on two soil moisture

3.4 Clods volume

The analysis of variance carried out on the volumes of clods on the plots indicates a very highly significant difference between the first two speeds (2.2 and 5.1 km.h^{-1}) and the fastest (10.0 km.h^{-1}) with tillage carried out at 12% moisture (Fig. 7). For tillage at 9% moisture, there is a very highly significant difference between the size of the clods on the slow speed plot (3.8 km.h^{-1}) and those of the clods on the other plots (5.1 and 9.9 km.h^{-1}).

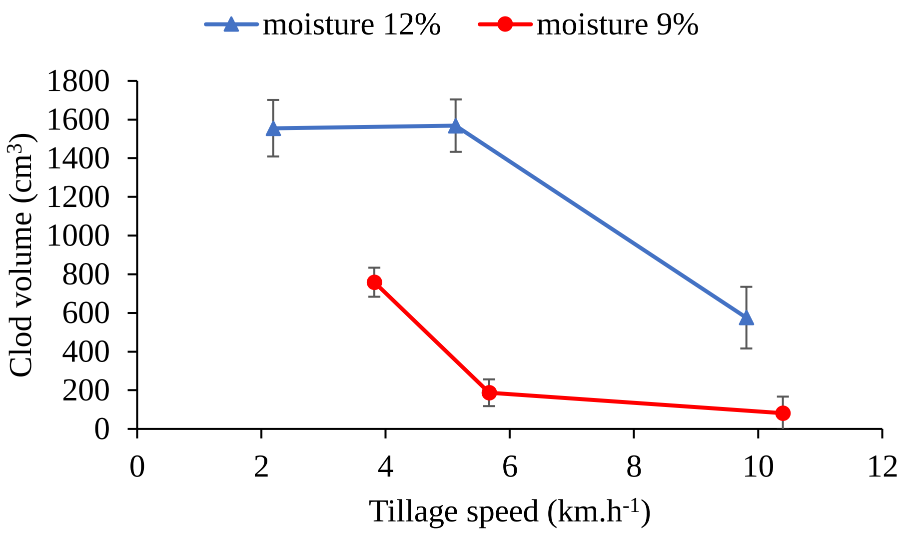

Fig. 7: Variation of clods volume at two soil moisture levels and tillage with a disc harrow

IV. DISCUSSION

4.1 Optimization of the use of the tool

The measurement of the traction force made it possible to have the average at a traction effort of 315 daN with the harrow with 16 discs of 550 kg. At 12% soil moisture the average tillage depth is 6.52 cm. With a tillage width of 210 cm, the soil cutting section is 6.52 cm x 210 cm i.e., 1369 cm². The soil cutting force is 0.23 daN by cm². It is then possible to increase the labor width by 90 cm to reach 300 cm. This will provide a traction force of 449.9 daN. The weight of the tool will increase but would still be within the lifting capacity of the tractor, which is 2200 kg. Labor time per hectare would then be reduced.

4.2 Labor time

The labor time per hectare goes from 3.9 h at 2.2 km.h^{-1} to 1.1 h at 10 km.h^{-1}. Faster the tool passes, the lower is the time spent per hectare. Service providers using the discs harrow have their contract carried out per hectare [15, 2]. Faster is the tillage speed, larger are the tillage surfaces and higher is the gain for the operator. But the high speed does not seem favorable to maintaining the surface roughness in the climatic conditions of the central region where the rains are often high intensity [8]. The solution of increasing the tillage width considering the traction force makes it possible to reduce the labor time per hectare even the tillage is done at moderate speeds. A tillage speed at around 6 km.h^{-1} makes it possible to do 1.6 h.ha^{-1} with the width of the tool of 210 cm. With a width for the tool of 300 cm, the labor time at the same speed would be 0.44 h.ha^{-1} or approximately 30 min.ha^{-1}.

4.3 Variation of soil surface roughness

The variation of the roughness index is a function of the speed. It is also a function of the moisture of the soil at the date of the tool passage. At the favorable moisture limit for wet tillage on this soil (12%) [10], roughness indexes varied from 1.19 to 1.27. This value is close to that obtained by [3] on the mechanized zaï plot in Saria, which was 1.28. With the tillage on the soil at 9% moisture, the roughness index at a speed of 3.8 km.h^{-1} is high (1.26), but with the tillage at 5.8 km.h^{-1} the roughness index is lower (1.16) and it reaches 1.06 at 10.40 km.h^{-1}. The moisture of 9% is close to that of the state of friable consistency soil [10]. The action of the discs on the soil at this state of consistency favorable to the bursting of the clods, gives small particles of soil [16]. This makes the plot more vulnerable to water erosion. After the rain of 8.5 mm, the roughness index reduction was 4.26% and 4.62% respectively on the plot treated at slow speed (2.2 km.h^{-1}) and that treated at medium speed (5.1 km.h^{-1}). Despite this reduction, the index is still higher than that of the high-speed tillage. The large size of the clods on these plots allows them to retain some of the roughness after the rain. The graphs in Fig. 4 show the variation of the sizes of the clods with the two soil tillage's moisture levels. The clods are large with low and medium speeds at 12% moisture (1550 cm^3). But with high speeds around 10 km.h^{-1} they are reduced (550 cm^3). For moisture of 9% the sizes of the clods are smaller. These results are conformed to the observations made by [17] on the reduction of clods sizes. It varies from 760 cm^3 for the lowest speed to 81 cm^3 for the high speed. There are very small clods. This confirms the fact that speeds from 10 km.h^{-1} destroy more clods, especially on soils with low moisture. This makes them susceptible to runoff and erosion [18].

V. CONCLUSION AND PERSPECTIVES

The discs harrow's speed of 10 km.h^{-1}destroys the clods. The roughness index is low on the plots treated under these conditions. The increase in speed is more harmful for the surface roughness when the soil moisture is low, i.e., close to that of the state of friable consistency. Labor time is reduced by rapid tool passage. Given the fact that the disc tool has a relatively low traction effort regarding the width the pass, it is possible to reduce the labor time per hectare by increasing the tillage width of the tool while remaining within the average speed of 6 to 7 km.h^{-1}. Increase discs axes length could save time by carrying out the tillage of a hectare in a short time even at 6 km.h^{-1}. Training users is important in order to explain to them the impact of the misuse of the tool on the environment in the short term and also on their economic activity in the medium term.

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REFERENCES

[1] Ouédraogo, I. (2012). Importance de la mécanisation agricole et son incidence sur les rendements du cotonnier et sur certaines caractéristiques chimiques du sol dans les agro-systèmes cotonniers Centre (FASO COTON) et Ouest (SOFITEX) du Burkina Faso. Mémoire d'ingénieur Agronome, UPB/IDR16, Burkina Faso. 67 p.

[2] Sanou, F., Havard, M., Coulibaly, K., Nana, S. (2019). Effets de l'introduction du tracteur sur les pratiques agricoles en zone cotonnière du Burkina Faso. In : Soumaré et Havard (sous la direction de). Actes du colloque les zones cotonnières africaines, dynamique et durabilité, 21 au 23 novembre 2017, Bamako, Mali. pp 237-251.

[3] Barro, A., Zougmoré, R., Sédogo, M. P. (2009). Evaluation de la faisabilité de trois types de travail du sol :application du

modèle SARRA dans le Plateau Central au Burkina Faso. Sécheresse ; 20 (4) : 338-345.

[4] Centre national du machinisme agricole, du génie rural, des eaux et des forêts (CEMAGREF). (1993). Les matériels de travail du sol, semis et plantations, CEDRA Camille. Collection: CEMAGREF– FORMAGRI, ISBN : 2-85362-348-3. - 384 pages.

[5] Angonin, B. (2019). Règles de base de l'utilisation du tracteur. Chambre d'Agriculture de Nouvelle Calédonie Plateforme Machinisme Agricole. 55p. https://www.province-sud.nc › default › files › PPAP-Docs › Machinisme septembre 2019.

[6] Roose, E. (1994). Introduction à la gestion conservatoire de l'eau de la biomasse et de la fertilité ´ des sols. Bulletin pédologique FAO, n˚ 70. Rome : FAO

[7] Zougmoré, R., Gnankambary, Z., Guillobez, S., Stroosnijder, L. (2002). Effect of stone rows on soil chemical characteristics under continuous sorghum cropping in semiarid Burkina Faso. Soil & Tillage Research 66: 47-53.

[8] Zougmoré, R., Mando, A., Stroosnijder, L. (2004). Effect of soil and water conservation and nutrient management on the soil-plant water balance in semi-arid Burkina Faso. Agricultural Water Management; 65 : 103-20.

[9] Fontes, J., & Guinko S. (1995). Carte de la végétation et de l'occupation du sol du Burkina Faso, note explicative, Ministère de la coopération française, Toulouse, France, 67 p.

[10] Barro, A. (1999). Evaluation de l'effet et de la faisabilité du travail du sol sur le sorgho photosensible à Saria (Burkina Faso). Thèse de doctorat, ENSA, école doctorale de biologie intégrative. Montpellier 1999. 175p.

[11] Food and Agriculture Organization of the United Nations, (FAO). (2006). World reference base for soil resources: a framework for international classification, correlation and communication. Edt. 2006. Rome. www.fao.org/3/a-a0510e.pdf.

[12] Ikazaki, K., Nagumo, F., Simporé, S., & Barro, A. (2018): Soil toposequence, productivity, and a simple technique to detect petroplinthites using ground-penetrating radar in the Sudan Savanna. Soil Science and Plant Nutrition, DOI: 10.1080/00380768.2018.1502604

[13] Hien, E. (2004). Dynamique du carbone dans un Acrisol ferrique du Centre Ouest Burkina : Influence des pratiques culturales sur le stock et la qualité de la matière organique. Thèse de Doctorat, ENSA Montpellier, 138 p.

[14] Jester, W., Klik, A. (2005). Soil surface roughness measurement methods, applicability, and surface representation. Catena, 64(2-3) : 174-192. DOI : http ://dx.doi.org/10.1016/j.catena.2005.0 8.005.

[15] Gnamou, Z. (2017). Le travail du sol dans le contexte du changement climatique dans les régions centre et nord du Burkina Faso ; mémoire d'ingénieur d'agriculture ; Centre Agricole Polyvalent de Matourkou/Burkina Faso; p 103 + annexes.

[16] García Moreno, R., Díaz Álvarez, MC., Tarquis, AM., Barrington, S., Saa Requejo, A. (2008). Tillage and soil type effects on soil surface roughness at semiarid climatic conditions. Soil Till. Research, 98(1): 35-44. DOI: http://dx.doi.org/10.1007/ s40333-013-0246-z.

[17] Barro, A., Sanou, F., Ouédraogo, J., Simporé, S., Nacro, H.B. (2020). Effets de la vitesse du pulvériseur à disques sur l'état de surface d'un lixisol sablo argileux à la station de Saria au Burkina Faso. Symposium international sur la science et la technique, CNRST, Ouagadougou 14 au 18 octobre 2019. Spécial hors-série n° 5 janvier 2020, science et technique, sciences naturelles et appliquées p45-53

[18] García Moreno, R., Saa Requejo, A., Durán Altisent, J.M., Díaz Álvarez, MC. (2011). Significance of soil erosion on soil surface roughness decay after tillage operations. Soil & Tillage Research, 117: 49-54. DOI: http://dx.doi.org/ 10.1016/j.still.2011.08.002.