AGRICULTURAL STRUCTURES AND MECHANIZATION

Dr. A.K. Singh

ALEXIS PRESS
JERSEY CITY, USA

AGRICULTURAL STRUCTURES AND MECHANIZATION

AGRICULTURAL STRUCTURES AND MECHANIZATION

Dr. A.K. Singh

ALEXIS PRESS

ALEXIS PRESS

Published by: Alexis Press, LLC, Jersey City, USA
www.alexispress.us

First Published 2022

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication Data

Includes bibliographical references and index.

Agricultural Structures and Mechanization by *Dr. A.K. Singh*

ISBN 978-1-64532-768-4

CONTENTS

CHAPTER 1

AN OVERVIEW OF NEW SEMIAUTOMATIC LONGAN FLESH PEELING AND SEED REMOVAL MECHANISM

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

This research introduces a semiautomatic method for simplifying the peeling and seed removal of dried longan, a popular fruit with a sweet and aromatic flavor. The traditional manual method is labor-intensive and time-consuming, limiting large-scale production. A mechanical solution combines automation's effectiveness with human intervention's dexterity. The automated flesh peeling and seed removing apparatus consists of robotic arms, a conveyor belt system, and advanced image processing algorithms. The system uses high-resolution cameras to identify the best locations for peeling and seed extraction, while the robotic arms carefully peel the outer skin to reveal the flesh inside. The system also extracts seeds precisely, minimizing risk to the fruit. The mechanism includes machine learning algorithms that improve fruit identification and peeling procedures over time. Initial testing has shown a significant decrease in labor needs and processing time compared to the conventional manual method. The semi-automatic process preserves the dried longan fruits' integrity and quality, retaining their flavor and aesthetic value.

KEYWORDS:

Flesh Peeling, Seed Removal, Fruit Processing, Automation, Agricultural Technology, Fruit Industry.

INTRODUCTION

An evergreen tree from the Sapindus family called the longan is planted for commercial fruit production. Produced in tropical nations, mainly Thailand and China, longan fruit is highly nutritious and valuable commercially. Because it contains numerous biologically active substances and nutrients, longan pulp can be used in traditional Chinese medicine to enhance blood metabolism, alleviate sleeplessness, and prevent amnesia. Asia's primary supplier of longan right now is Taiwan. Summer is the primary growing season for longans. Because of the weather, newly harvested longans are frequently hot and damp, which causes the fruit's quality to decline quickly. The pulp will slowly start to seep juice and lose its freshness after a little window of time. The quality, freshness, and value of the pulp are significantly impacted by this phenomenon, also known as pulp autolysis or pulp decomposition. Longan is generally treated to increase its shelf life and simplify storage. Longan is usually dried out by baking; dried longan can be kept for a longer time and used to make jams, wines, and canned foods [1].

Shelled and unshelled longans are baked using different techniques. Longan is traditionally picked, shelled, and then baked in Thailand. The longan that has been shelled is dried in hot air for 12–15 hours at 70°C. The longan's final moisture content can reach 22%. Golden color characterizes the dried longan pulp. The finished moisture content of the shelled longan can be as low as 22% after 48–52 hours of drying in hot air at 75 °C. In Taiwan, shelled longans are

often roasted in-hand using either hot air baking or smoking. Regardless of the procedure, the dried longan will smell smokey and have dark brown pulp when the shell is removed.

Currently, employees still separate the seeds from the pulp of dried longans by hand. The longan pulp has a high sugar content and becomes exceedingly viscous after being dried in hot air. The fruit's amorphous nature makes extracting the seeds more challenging. The longan is often heated before manual seeding. The seeds are extracted by making a hole in the pulp with a knife. The operating process is labor-intensive and takes a long time. Human resources have been drastically reduced as a result of changes in the rural population structure, especially the aging of the farming community, and physical separation of the seed and pulp may raise issues with food hygiene and safety. Artificial longan deseeding procedures can be efficiently replaced by machines, which will lower prices and enhance production efficiency, food cleanliness, a shortage of human resources, and other difficulties [2]. Research on longans mostly concentrates on its chemical and physical characteristics. There hasn't been much research on seeding machinery, and there isn't a completely commercialized system on the market either. A seed-removing device for freshly shelled longans was created by Xie et al. (2006) using air pressure as a power source to drive a pneumatic cylinder, which in turn drove a triangular blade to cut the longan along with its pulp [3].

The pneumatic ejector bar then completes the task of extracting the longan seeds by pushing them out. The thickness of the blade will have an impact on the size of the cut for the fresh longan seeds. The fresh longan cut may not be complete and the seeds may not be removed if the cutting blade is too thick or thin. The diameter and speed of the ejector bar after the fresh longan is cut will also have an impact on the success of the seeding and the rates of pulp loss. Pen et al. (2012) used a pneumatic cylinder as a power source to drive the triangular cam and simulated finger-drawing arcs to peel off dried longan flesh. The L-shaped bracket's two ends are fitted with symmetrical pulp peeling arc blades, and the cam controls their opening and closing. The pulp of the longan will be split open by the two arc blades so that a rod ejector can discharge the seeds. The success rate of pulp peeling will be influenced by the depth of occlusion between the two arc blades and the dried longan pulp, the speed at which the L-shaped bracket opens and closes, and the velocity at which the longan seeds are ejected from the ejector bar [4].

With the help of a suitable cutter, this study will construct a set of semi-automatic dried longan pulp peeling machines. Also mentioned is the connection between the cutter's shape, speed, and success rate when cutting dried longans. A silicone soft board is built with a lifting mechanism to finish the seed removal process. To peel the pulp and get rid of the seeds, the dried longan is extruded via this board. The process with the highest success rate and quickness was discovered. Future studies on the machinery used to process dried longans can use the semiautomatic device developed in this study as a model [5].

Materials and Methods

i. Dried Longan Sample

Conical, heart-shaped, spherical, and other morphologies are possible for mature longans. Some species have a side that is noticeably longer than the other. The fruit's appearance will become rough and wrinkled after drying. The dried longan will have an uneven shape, with flesh that is near to the inner core and about spherical or oval in appearance. We conducted this study using dried longans that were commercially available as our experimental material. Every sample used in the experiment was chilled. Before usage, they were brought to room temperature to reabsorb moisture, then heated to 60.0 C in an oven to lessen the viscosity of

the pulp. The flesh peeling and seed removing mechanism created in this study was tested using dried longans. The average diameter of dried longan seeds was 14.95 mm and 17.20 mm for longan samples (pulp containing seeds) [6].

ii. Experimental Equipment

A direct current (DC) motor (JGB37-550) with a maximum output of 60 W and a motor driver (VNH2SP30) work together to power the cutting tool of the dried longan pulp peeling machine. A stepping motor driver (AZD-CD, Oriental Motor Co., Ltd., Taiwan) and a stepping motor (AZM66AC-TS7.2, Oriental Motor Co., Ltd.) operate the lifting mechanism for peeling the pulp and removing the seeds. A silicone soft board is then used to peel the pulp and remove the seeds once the dried longan has been clamped, fixed, and squeezed into position using the lifting mechanism. An Arduino UNO controller is used to control the DC motor. Using a computer programming interface, the stepping motor and lifting mechanism positions are managed. The semiautomatic flesh peeling and seed removing equipment uses roughly 480 W of power. The soft board is manufactured of C-25 silicone (Asia Silicone Chemical Materials Co., Ltd., Taichung, Taiwan) and is 50 x 50 mm in size. It has a tensile strength of 50 kg/cm2, a maximum elongation of 750%, and a hardness of 25 HA [7].

iii. Semi-Automatic Dried Longan Pulp Peeling Machine

Aluminum extrusion serves as the foundation for the semi-automatic dried longan pulp peeling and seed removing machine. The eccentric shaft turntable in Figure 1a is driven by a stepping motor. The dried longan can be precisely clamped by the stepping motor's control. The dried longan-fixing jaws will open when the eccentric shaft turntable motor turns upward. The dried longan is presently set on the pedestal. The dried longan will be clamped by the jaws while the eccentric shaft turntable is rotated downward. The DC motor begins to drive the reciprocating link of the cutting tool to chop the pulp once the dried longan has been fixed. The longan pulp has been chopped due to the machine's small size, and as seen in Figures 1a and 1b, a silicone soft plate has been inserted along the aluminum extrusion groove. The dried longan in the holder is cut and squeezed with the silicone soft plate, and the longan seeds will pass through the hole as the eccentric shaft turntable is turned up to the top to peel the pulp. Following the separation of the longan pulp and seeds, the longan pulp will remain beneath the silicone soft board and the longan seeds will be added to the top of the soft board through the hole in the soft board, as illustrated in Figure 2.

iv. Design of the Dried Longan Pulp Cutting Tool

The easier it is to remove the seeds during hand longan peeling, the bigger the hole in the pulp. Figure 3 illustrates the design of a longan-chopping tool used in this investigation. The bending angle and cutting surface breadth of the knife were altered. The dried longan pulp was subjected to a hole-cutting test using a knife drive mechanism. We evaluate it using the shear-stress theory because the production and separation of chips during the cutting process are caused by the material being subjected to the greatest shear stress. Material is cut by shear force when the tool and the cutting workpiece move in relation to one another. Shear surface is the name of this cutting surface. The chip layer is thinner at greater shear angles, which reduces friction. Additionally, less cutting force is needed. In contrast, smaller shear angles result in a thicker chip layer, which increases friction. The cutting force is considerable. Therefore, a cutting instrument for dried longan pulp was created for this study [8], [9].

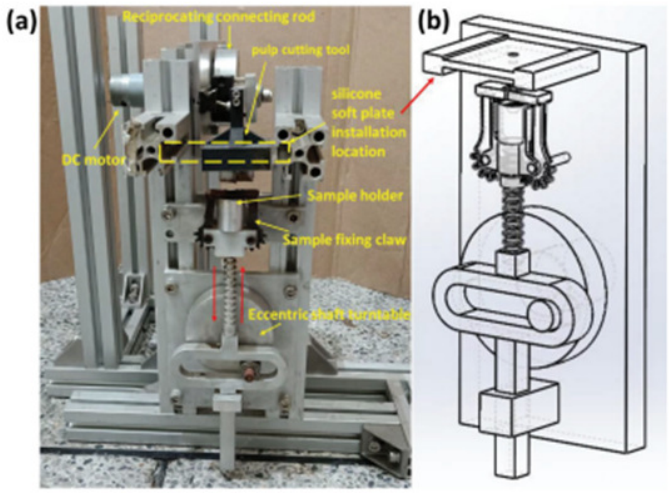


Figure 1: (a) Semiautomatic dried longan peeling machine (b)Schematic of the installation position of the silicone soft board peeling.

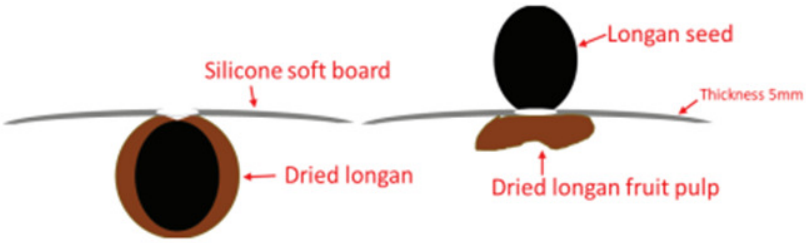


Figure 2: The pulp hole and the silicone soft board are pushed against each other after the dried longan has been cut. The pulp will remain underneath the silicone soft plate while the longan seeds are extruded to the other side. The seeds and the flesh will separate.

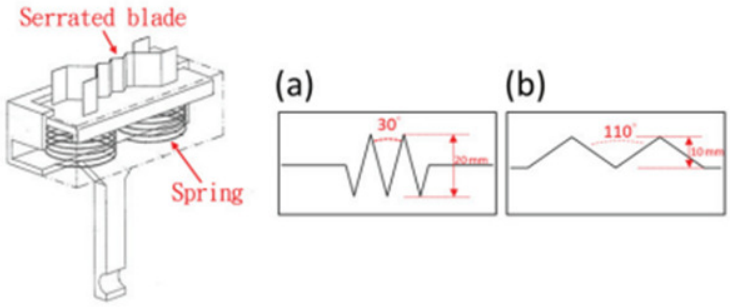


Figure 3: A diagram of a pulp-chopping device for dried longans. A cutter with a blade that is 20 mm wide and has a 30-degree serrated bending angle. (b) A cutter having a blade that is 10 mm wide and has a serrated bending angle of 110°.

As seen in Figure 3, our cutting tool is constructed from an aluminum foil sheet and a spring. The spring serves as an extrusion buffer and aids in tightening the fit between the knife edge and the longan pulp to prevent the cutter from unduly pressing the longan seeds during

pressing. Two different knife types were created for testing in this investigation. The first has a 20 mm cutting surface width and a 30° serration bending angle; the second has a 10 mm cutting surface width and a 110° serration bending angle. The two knives are compared in Figure 3. Different knife specifications are tested at the same cutting speed to determine which is best for chopping dried longan pulp. In the next section we will continue our discussion about the mechanism in detail [10].

DISCUSSION

Design of the Cutting Tool's Driver Mechanism

The Scotch Yoke mechanism is used for cutter actuation, and a DC motor is employed to transform circular motion into linear reciprocating motion. The cutter-driven stroke seen in Figure 4 is meant to be matched by the linear reciprocating mechanism. The shaft propels the rod in a linear reciprocating motion to execute the opening process as the motor rotates the disk. The driving rod goes forward and creates a maximum stroke of 45 mm when the disk rotates through 0 to 180; the rotation range is between 181 and 360; and the rod returns to the origin at 360. The cutter's maximum stroke is 68.6 mm, and the eccentricity of the eccentric shaft turntable is 34.3 mm.

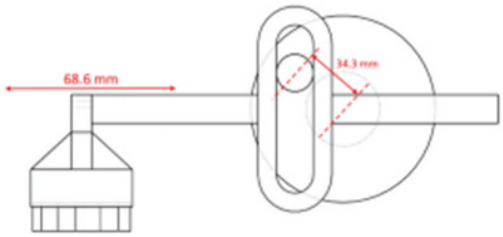


Figure 4: Dried longan Pulp Cutter Reciprocating Scotch Yoke Mechanism.

Dried Longan pulp Peeling and Seed Removing Mechanism

The linking mechanism of a wine opener served as inspiration for the mechanisms that remove seeds and peel pulp. The primary support system secures the aluminum extruder to the aluminum plate. Stepping motor rotation drives eccentric shaft disk rotation. The row of teeth on the lifting mechanism will be driven by the eccentric shaft turntable in order to synchronously drive the ratchet, which will open and close the clamping arm. The turntable's shaft has a 34.3 mm eccentricity and a 68.6 mm maximum displacement stroke. Over the lifting rod, a material holder with a ball socket is available for holding the dried longan. A row of teeth are installed on the lifting rod's side to drive the clamping arm. A semicircular ratchet for gear transfer is located on the lower end of this arm. Clamping jaws are installed on the clamping arm's upper end to secure the dried longan in a clamped position. A hole is cut in the pulp of the dried longan after it has been clamped and fastened in order to remove the seed. The clamping height is set to 11.2 mm to prevent the dried longan from turning while being opened, as shown in Figure 5, given that the dried longan's average height is around 16.8 mm. To get good peeling, the dried longan must fit through the silicone soft board about two-thirds of the way. Given that the silicone soft board has a thickness of 5 mm, the mechanism's stroke must be at least 16.2 mm, and the total mechanical stroke for the peeling process must be at least 27.4 mm, as shown in Figure 5.

Figure 5: Schematic of the dried longan's clamping position

After the hole is drilled, the stepping motor drives the eccentric shaft turntable, which raises the lifting rod. The row of teeth simultaneously causes the clamping arms to open, the material base to shift upward, and the ratchet wheel of the clamping arm to revolve downward. The lifting mechanism raises the dried longan in the material holder. The dried longan has an average diameter of 17.2 mm. A 6 mm through-hole silicone soft plate is used to squeeze the dried longan and the silicone soft plate. The dried longan pulp along the seed's surface will be scraped off by the plate's bending and flexibility. Figure 6 illustrates how the longan seeds will separate from the pulp via the plate's opening and emerge on the other side.

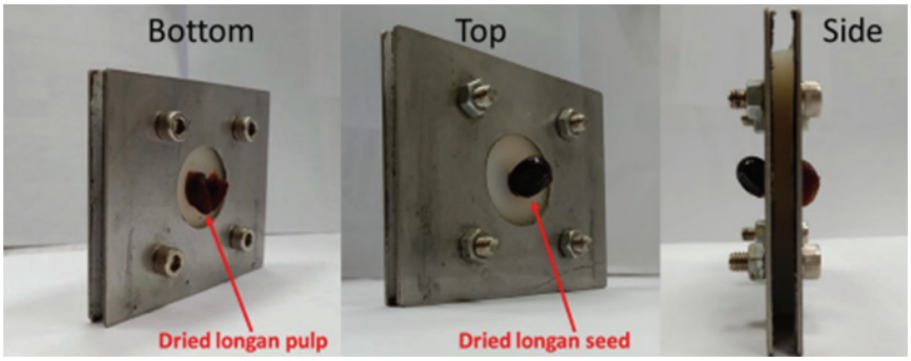


Figure 6: The pulp and seed are separated after the dried longan is forced through the 6 mm hole of the silicone soft board.

Success Rate of Cutting with the Designed Machine

The effectiveness of following peeling and seeding operations will be impacted by the size of the holes created by the longan pulp cutting knives. The dried seeds may break when cutting the longan pulp due to an inconsistent amount of force being exerted by the blade. The pulp is sticky because it contains a lot of sugar. The longan seeds will adhere to the pulp if they are broken and shredded, making planting impossible. The definitions of success and failure in this situation are shown in Figure 7. Either (a) or (b) the knife hole in the dried longan pulp is successful. The seed is plainly visible in Figure 7a if a hole is correctly cut with the knife into the dried longan pulp; otherwise, it is not visible in Figure 7b.

As depicted in Figure 8, two distinct cutting tools were created for this study. The tool used to cut longan pulp is powered by a DC motor. 60 dried longans are utilized for the test, and the tool's speed is set to 508 mm/s. The test results are shown in the table given below. The cutter with a cutting surface width of 20 mm and a serrated bending angle of 30 forms an average 7.4 mm wide longan pulp breach; its success rate is 85% and its seed breakage rate is 11.7%. The average breach width is 5.5 mm, the success rate is 63.3%, and the seed breakage rate is 31.5% for the cutter with a cutting surface width of 10 mm and a serrated bending angle of 110.

The cutter with a 30° serrated bending angle has a wider cutting range than the cutter with a 110° serrated bending angle. The former tool readily adheres to the pulp, but this has no impact on how the pulp is opened. The tool with a 30-degree bending angle has a good success rate for cutting holes while minimizing breaking of longan seeds. Larger breaches in the pulp allow the smooth surface of the longan seeds to be readily seen, making it easy to peel the pulp and remove the seed, according to experience with manual pulp peeling and seed removal. Therefore, the 30-serrated knife was employed in the subsequent studies.

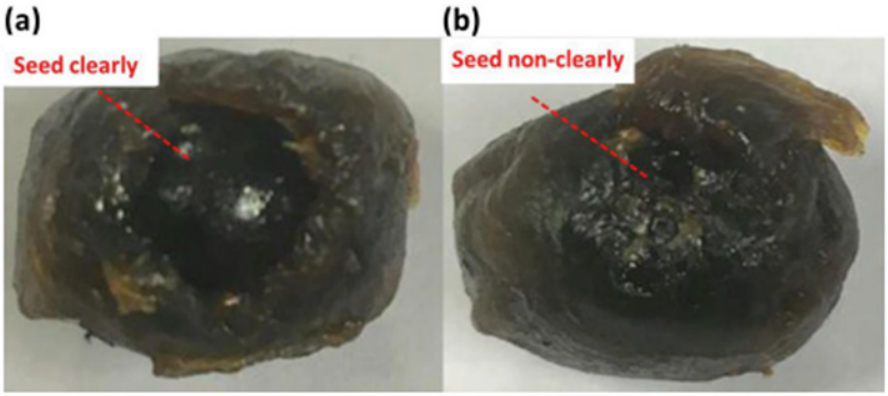


Figure 7: The hole cut in the dried longan pulp: (a) successfully; (b) fails.

	Average Width of the Breach (mm)	Cutting Success Rate (%)	Seed Damage Rate (%)
Blade width is 20 mm; Serrated bending angle is 30°	7.4	85.0 (51/60)	11.7 (7/60)
Blade width is 10 mm; Serrated bending angle is 110°	5.5	63.3 (38/60)	31.7 (19/60)

Figure 8: Cutting tool test results for dried longan.

Success Rate of the Cutting Tool with Operating Speed

By adjusting the DC motor's power supply voltage through pulse width modulation (PWM), the Arduino UNO controller can change the speed of the longan pulp cutter. The DC motor's speed and cutting force increase in direct proportion to the PWM duty cycle. The ideal cutting speed for dried longan pulp was determined using a 20 mm wide cutter with a 30° serrated bending angle. At speeds of 292.0, 330.0, 380.0, and 508.0 mm/s, the experiments were run. We evaluated each speed using 60 dried longans. Figure 9 displays the outcomes. At 292.0 mm/s cutting speed, the average breach width is about 7.5 mm, and the success rate is roughly 95.0% (57/60). There are no cracked seeds in the test sample. The breach's average width is roughly 7.3 mm when the cutting speed is 330.0 mm/s, the success rate is roughly 85.0% (51/60), and the seed breaking rate is roughly 10.0% (6/60). The average breach width when the cutting speed is 380.0 mm/s is about 7.5 mm, the cutting success rate is around 80.0% (48/60), and the seed breakage rate is about 15.0% (9/60). The success rate is around 85.0% (51/60), the seed breakage rate is approximately 11.7% (7/60), and the average breach width is approximately 7.4 mm when the cutting speed is 508.0 mm/s. According to the test results, slowing down the blade's movement increases cutting success and lowers seed breakage. The maximum success rate without longan seed breakage is obtained at a cutting speed of 292.0 mm/s.

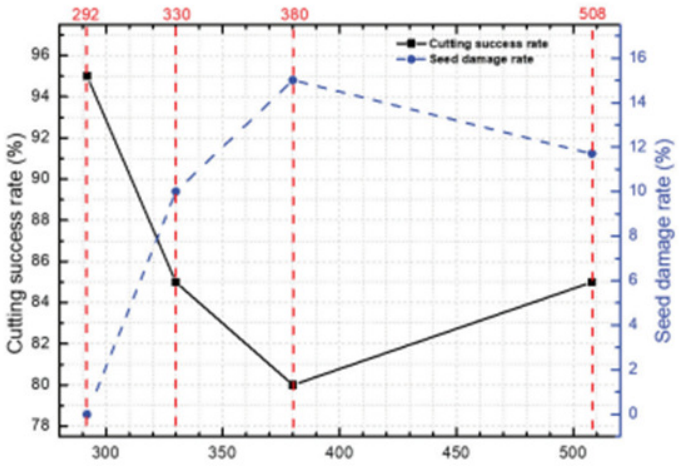


Figure 9: At various cutting speeds, the tool's success rates with a 20 mm width and a 30 sawtooth bending angle.

Test Analysis of Peeling Dried Longan Pulp

The lifting and clamping mechanism is propelled by a stepping motor. With a 30° bending angle and 292 mm/s speed, a serrated cutter is used to slice the dried longan pulp. The lifting mechanism forces the dried longan up against the 6 mm hole in the C-25 silicone soft plate, causing the seed to detach. The peeling success rate is evaluated in relation to the variation of the upward pushing speed of the lifting mechanism. The successful peeling of the pulp is determined by the total separation of the dried longan pulp and seed, which is tested using 60 longans per group. The experiment is deemed unsuccessful if the longan seeds still include pulp, are fractured as a result of pushing, or cannot be separated from the pulp.

According to Figure 10, at a pressing speed of 70.0 mm/s, the success rate of peeling is roughly 66.7% (40/60), whereas the failure rate is roughly 33.3% (20/60). Twenty dried longans' pulp peeling attempts failed. Twelve of these failed because the seeds still had pulp on them, two failed because the seeds were fractured, and six failed because the seeds did not slide through the silicone plate smoothly. The peeling success rate is 70.0% (42/60) and the failure rate is roughly 30.0% (18/60) when the pushing speed is 56.0 mm/s. Twelve of the unsuccessful seeds still had pulp, two were damaged, and four were unable to pass through the silicone soft board. The peeling success rate is 80.0% (48/60) and the failure rate is 20.0% (12/60) when the pushing speed is 42.0 mm/s. Six of the unsuccessful seeds still had pulp, two were crushed, and four were unable to pass through the plate. The peeling success rate is roughly 86.7% (52/60) for a pushing speed of 28.0 mm/s, and the failure rate is 13.3% (8/60). Four of the unsuccessful seeds still had pulp, two were cracked, and two were unable to pass through the plate. Peeling success rates are at 86.7% (52/60) and failure rates are roughly 13.3% (8/60) with pushing speeds of 14.0 mm/s. No samples were rejected because they could not pass through the flexible silicone plate, although two seeds fractured due to pushing, and six seeds still had pulp on them.

The experiment demonstrates that slowing down the pressing motion will increase the success rate of pulp peeling. If the lifting speed is too high, the dried longan may fall off the holder as it passes through the plate. Some of the seed will not be extracted since there is not enough time for it to pass through the perforations. Both 28 and 14 mm/s are equally effective for the dried longan peeling and seeding process, thus 28 mm/s is recommended for efficiency. Based

on our findings, we advise breaching the pulp at a speed of 292.0 mm/s using a tool with a cutting surface width of 20 mm and a sawtooth bending angle of 30.

After being chopped, the dried longan should be seeded by squeezing it with a silicone soft plate at a speed of 28 mm/s. To confirm the mechanical stability, further 100 dried longan samples were prepared for testing. With a failure rate of 14%, peeling was shown to have an overall success percentage of 86.0%. Three of the unsuccessful seeds still had pulp on them, while 11 seeds were unable to pass through the plate. When the dried longan pulp was sliced, it was determined whether the cut had succeeded if the dried longan seeds were shattered or impossible to be seen clearly. Following cutting, the dried longan and silicone soft plate were unable to pass through the silicone soft plates through hole, as indicated. This resulted in residual pulp on the seed surface and dried longan seed breaks that were deemed to have failed peeling. Future study can use the speed settings for the semi-automatic flesh peeling.

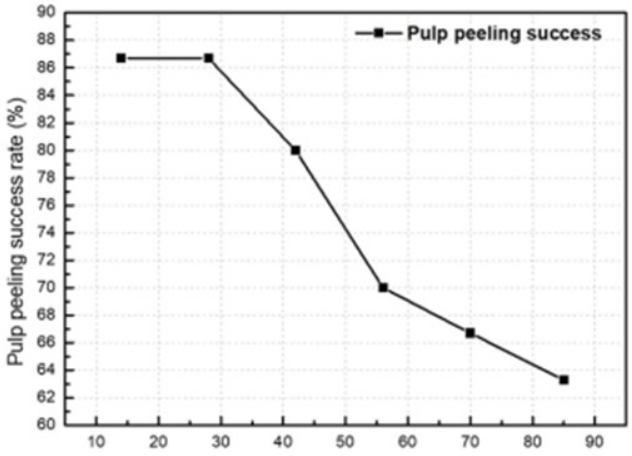


Figure 10: Dried Longan Pushing Speed (mm/s).

CONCLUSION

In conclusion, the creation of a revolutionary semiautomatic mechanism for dried longan seed removal and flesh peeling represents a significant development for the longan processing sector. This mechanism provides an effective and precise answer to the labor-intensive and time-consuming peeling and seed removal procedure by integrating automation, cutting-edge image processing, and robotic arms. The suggested mechanism shows good results in terms of lowering labor costs and processing times while preserving the caliber and consistency of dried longan fruits. The system can tolerate changes in fruit size, shape, and texture through ongoing learning and adaptation, resulting in consistent peeling and seed removal results. The processing of dried longans could be streamlined with this semiautomatic method, helping to satisfy the rising demands of consumers around the world. This technique enhances the economic viability of longan growers and processors while also contributing to the expansion and sustainability of the longan industry.

REFERENCES

[1] A. Fadeyibi and O. F. Ajao, "Design and Performance Evaluation of a Multi-Tuber Peeling Machine," AgriEngineering, 2020, doi: 10.3390/agriengineering2010004.

[2] O. Seth, "Issue 02," North Am. Acad. Res., 2020.

[3] A. O. Afolabi and M. L. Attanda, "Development and Performance Evaluation of Irish Potato Peeling Machine," J. Eng. Res. Reports, 2020, doi: 10.9734/jerr/2020/v18i317209.

[4] O. Seth, "A Review on the performance of some cassava peeling machines developed," North Am. Acad. Res. J., 2020, doi: 10.5281/zenodo.3669373.

[5] N. Hashimoto, S. Murakami, K. Yamaguchi, K. Sato, and Y. Araki, "Examination of enzymatic peeling in melting type of white flesh peaches," Nippon Shokuhin Kagaku Kogaku Kaishi, 2020, doi: 10.3136/NSKKK.67.451.

[6] J. Lee, J. P. Mattheis, and D. R. Rudell, "Storage temperature and 1-methylcyclopropene treatment affect storage disorders and physiological attributes of 'Royal Gala' apples," HortScience, 2016, doi: 10.21273/hortsci.51.1.84.

[7] N. Yokotani, M. Uraji, M. Hara, S. Hihara, T. Hatanaka, and K. Oda, "Low accumulation of chlorogenic acids represses reddening during flesh browning in Japanese peach 'okayama PEH7,'" Biosci. Biotechnol. Biochem., 2017, doi: 10.1080/09168451.2016.1234926.

[8] W.-S. Kim, T.-H. Kim, S.-J. Chung, and H. S. Choi, "(20) Effect of Fruit Dipping into Germanium Solution Just After Harvest on Fruit Quality of `Niitaka' Asian Pear," HortScience, 2019, doi: 10.21273/hortsci.40.4.993a.

[9] S. Murakami, K. Yamaguchi, and N. Hashimoto, "Ethylene facilitates boil-peeling in fruits," Food Sci. Nutr., 2019, doi: 10.1002/fsn3.1098.

[10] S. K. Vidyarthi et al., "A mathematical model of heat transfer during tomato peeling using selected electric infrared emitters," Biosyst. Eng., 2019, doi: 10.1016/j.biosystemseng.2019.07.001.

CHAPTER 2

AN OVERVIEW OF THE ABNORMALITY TOLERANCE PERFORMANCE ANALYSIS

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:
This study develops a picking end effector for well-known tea using negative pressure guidance, which improves posture and spatial positioning of tea buds. The end effector's deviation tolerance can increase the success rate of picking. The pre-experiment is planned, and the negative pressure range is set at 0.6 to 0.9 kPa. An orthogonal experiment is created, and different parameters are evaluated based on their impact on the average success rate. The best experiment factor-level combination is P = 0.9 kPa, D = 34 mm, and V = 20 mm/s. The average success rate of the end effector's negative pressure guidance is 97.36% within a 10 mm radius deviation range. This end effector can be used for deliberate tea selection and serves as a guide for creating similar picking end effectors for well-known tea.

KEYWORDS:
Abnormality Tolerance, Performance Analysis, End Effector Selection, Famous Tea, Tea Processing, Experimental Study.

INTRODUCTION

People all over the world adore tea since it is a natural health beverage. Famous tea is the cornerstone of the tea business and has a high drinking quality as well as economic advantages. The picking of common tea is currently automated; however, the picking of famous tea still requires manual effort. The "tea picker shortage" situation is getting worse due to the shrinking labor pool used for picking tea, which is restricting the growth of the tea sector. Recognizing that the mechanical plucking of famous tea is a necessary and unavoidable trend for the long-term sustainability of the tea business [1].

Research on the mechanical picking of renowned and good tea is still in the exploratory stage at the moment, and its primary focus is on the location and identification of tea buds. To identify tea buds, early research techniques generally relied on the color, shape, texture, and other qualities of tea leaves. Such techniques are inaccurate and have poor resilience. Deep learning has progressed quickly. Network models, like Faster R-CNN and YOLO, have been widely used by researchers to locate and identify tea buds on 2D images. Due to the tiny size, varied shapes, and complex growing environment of tea buds, many issues still need to be resolved, and algorithms' resilience, accuracy, and efficiency must be increased.

End effectors are vulnerable to issues such picking omission and picking error in the actual picking situations. Error compensation is therefore necessary. With a control accuracy of roughly 15 mm, Mehta and Burks presented a hybrid translation controller based on pursuit guidance. An effective strawberry harvesting end effector with high misalignment tolerance was created by Wang et al. The success percentage of the indoor picking test for this end

effector was 97.7%, and it can complete picking within a positioning error of 7 mm. In order to help with the fault-tolerant design of an end effector, Ye et al. devised a dynamic positioning error analysis approach, and the experiment was successful more than 90% of the time. The success rate of indoor and outdoor picking studies using Zou et al.'s restricted universal fruit-picking end effector was over 84% and 78%, respectively. A unique cable-driven gripper with sensing capabilities for strawberry-picking robots was created by Xiong et al. Three infrared sensors are installed in the gripper to correct the position mistake. The success percentage for collecting isolated strawberries in the field test was 96.77%. The approaches for error compensation outlined above mostly include visual servo to increase the end effector's picking range and multisensory cooperative positioning. However, they fall short in terms of positioning precision and area occupied when harvesting tea buds [2].

Unlike many other crops, famous tea is picked using branches and leaves rather than fruit. Applying conventional end effectors is challenging. New picking end effectors must therefore be developed. The intact rate of tea buds plucked according to Qin et al.'s picking end effector was about 76.6%. In the initial indoor experiment, the bionic picking finger created by Hao et al. had a picking success rate of almost 70%. Motokura et al.'s method of plucking tea involved a three-finger gripper attached to the end of a Kinova Jaco robotic arm. The majority of the picking end effectors for well-known tea now in use use certain basic mechanical structures and have subpar error-compensation capabilities, making it impossible to guarantee the success rate of picking and the intactness of tea buds. It is therefore vital to develop famous tea picking end effectors with a deviation tolerance. The purpose of this study is to investigate the famous tea's plucking method. The specific goals are to: investigate the famous tea's harvesting mechanism and develop a picking end effector with deviation tolerance performance based on negative pressure guidance; and establish a collection of methods for evaluating deviation tolerance performance as a guide for the development of similar end effectors [3].

Material and Methods

i. Physical Properties of Tea

The tea bud located above the third leaf node, or one-bud double-leaves, was the picking item in this investigation, as depicted in Figure 1. To enable the end effector to successfully pluck tea buds, it is required to ascertain the pertinent physical parameters of tea, including the overall dimension, shear force F, and average growth region area SA.

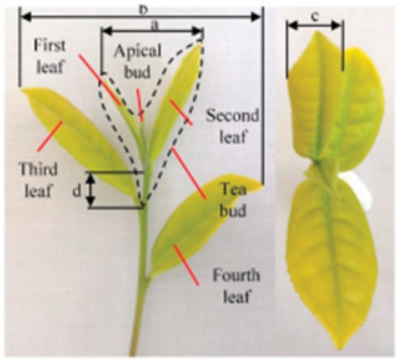


Figure 1: Schematic of tea characteristics parameters. Overall dimension: a first leaf span, b-second leaf span, c-leaf width, d- node spacing

On October 24, 2020, the Lishui Comprehensive Test Station of the National Tea Industry Technology System conducted measurements of tea's physical characteristics. As seen in Figures 2 and 3, 100 freshly plucked tulip tea leaves were used as measurement samples for the first five physical characteristics. The measuring equipment consists of a stem shear characteristic measuring tool and a digital caliper of the AIRAJ brand. The measurement device used by S_A is a 400 mm-long, square frame that was manufactured by hand, as illustrated in Figure 4. The frame is set up on the tea tree's canopy as the measurement method, and there are x tea buds in the frame. Formula (1) can be used to calculate S_A, and 20 measurements are taken in total [3].

$$S_A = \frac{400 \times 400}{x}, \quad (1)$$

x = the number of tea buds in the frame

Figure 2: Illustrate the Source of Measurement Samples.

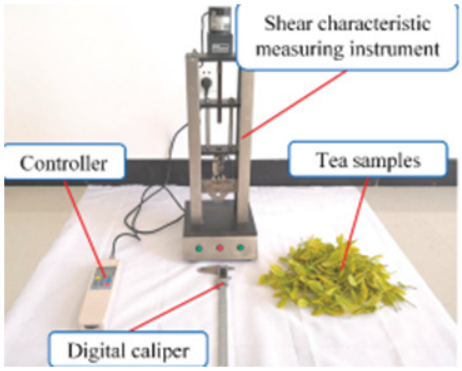


Figure 3: Illustrate the Measurement of the physical properties of tea.

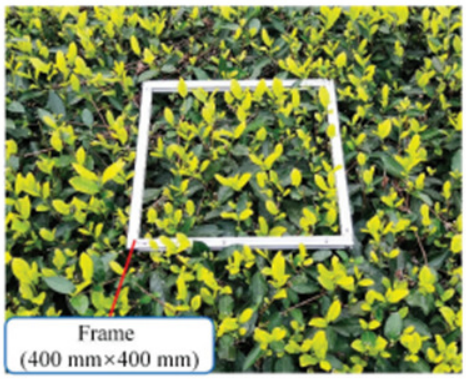


Figure 4: Measurement of average growth region area.

The statistical grouping of the measurement findings is depicted in Figure 5 and Table 1 respectively. The findings demonstrate that the tea buds exhibit significant individual variation, which impacts the effectiveness of negative pressure guidance. As a result, the end effector needs to be highly adaptable. Buds of tea grow at a distinct density. The end effector must avoid nontarget items because the average development region area of tea buds in the densest location is 3200 mm^2 [4].

Table 1: Statistical Table of the Physical Properties of tea.

Parameter Name	Statistical Parameters			
	Average Value	Maximum Value	Minimum Value	Standard Deviation
a (mm)	26.90	43.70	14.70	6.13
b (mm)	59.78	89.50	38.80	10.30
c (mm)	11.39	20.80	7.00	2.97
d (mm)	13.55	22.80	7.10	3.17
F (N)	7.64	10.56	5.15	1.17
S_A (mm^2)	4017.51	4571.43	3200.00	360.68

a—first leaf span, *b*—second leaf span, *c*—leaf width, *d*—node spacing, *F*—shear force, S_A—average growth region area.

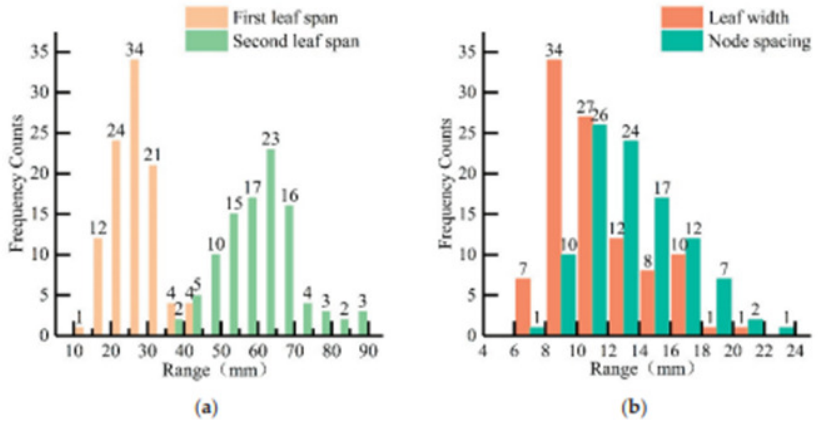


Figure 5: Frequency distribution of dimensions parameters. (a) Frequency distribution of first leaf span *a* and second leaf span *b*, (b) Frequency distribution of leaf width *c* and node spacing *d*.

DISCUSSION

i. End Effector Structure and Principle

The tea buds are primarily dispersed across the canopy surface in accordance with the growth characteristics of tea leaves. The top-down picking approach can thereby lessen interference. In this investigation, a negative pressure guidance approach was used to address positioning and random errors. The idea behind it is to use the airflow created by the negative pressure to draw the tea bud in. This circumstance can significantly raise the end effector's picking success rate.

Figure 6's depiction of the end effector, which includes the picking pipe, rope drive mechanism, and shearing mechanism, demonstrates how it was created while taking into account lightweight design criteria. As seen in Figure 7, the picking pipe was created using 3D printing, and a vacuum suction device was attached to the upper pipe entrance. The boss, the shear mechanism, and one end of the wire rope pipe of the rope drive mechanism were all fixed to the moving platform of the parallel manipulator, respectively [5], [6].

Figure 8 illustrates the components of the rope drive system, which also featured a steering gear, an Arduino Mega 2560, wire rope pipe, and wire rope. Its job is to power the shear mechanism so that the shearing task can be finished. Its benefit is that the driving source is mounted to the frame, easing the load on the parallel manipulator and preventing movement speed restrictions. As seen in Figure 9, the shearing mechanism used a gear transmission, and the wire rope was used to drive two specifically formed blades to finish the shearing. It has the advantages of being easy to drive, having a compact volume, and having the blade just below the bottom pipe opening. As a result, it is challenging to interfere in the initial and shear states.

To prevent interference during operation, the end effector rises above the designated shear point first. At this point, the vacuum suction machine starts to operate, creating negative pressure at the picking pipe's bottom pipe entrance. The end effector is moved to the shear point position by driving the parallel manipulator to drop vertically. The airflow produced by negative pressure is used in this operation to direct the tea bud into the plucking pipe. In order for the shearing mechanism to finish the shearing, the wire rope is driven to tighten while the steering gear is regulated to rotate. Through negative pressure, the tea buds are gathered. The shear mechanism returns to its initial position with the help of the spring at the same time that the steering gear is commanded to reset. Analysis was done on the end effector's operating system. When the negative pressure guiding is effective, there is very little chance that the shear will fail. As a result, the success rate of the negative pressure direction largely determines the success rate of choosing [7], [8].

The vacuum suction machine's negative pressure, the pipe diameter of the lower pipe opening, and the picking pipe's descent speed are the determining variables of the negative pressure guidance without taking placement mistake into account. According to the statistical findings, 92% of the samples were tea buds with a first leaf span of less than 35 mm. The diameter of the lower pipe opening may be slightly smaller than the initial leaf span when negative pressure guidance can shorten the leaf span. Therefore, the bottom pipe opening's minimum diameter is 30 mm. The second leaf span's minimum value was 38.8 mm.

To lessen the inhalation of nontarget objects like the third and fourth leaves, the maximum diameter of the lower pipe aperture was adjusted to 38 mm. Therefore, the lower pipe opening's pipe diameter range of 30-38 mm was established, and the three levels were set at 30, 34, and 38 mm, respectively [9], [10].

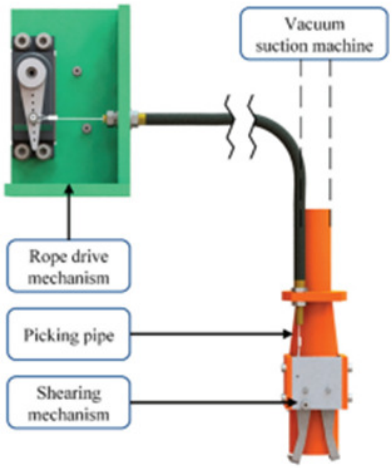


Figure 6: Illustrate the End effective.

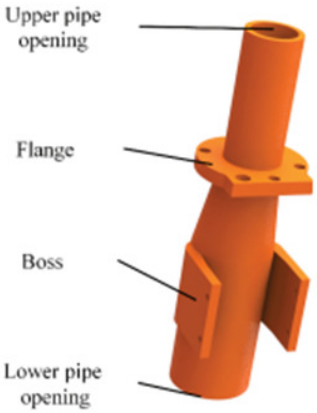


Figure 7: Illustrate the Picking pipe.

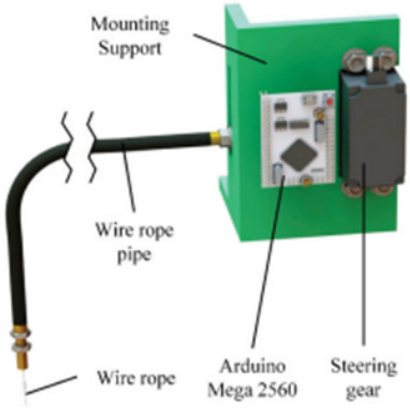


Figure 8: Illustrate the Rope drive mechanism.

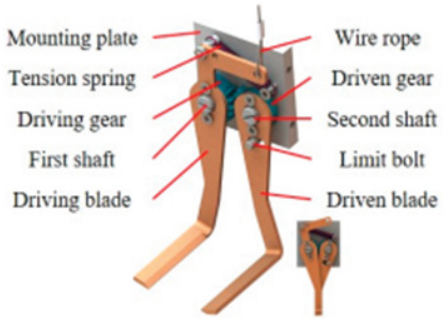


Figure 9: Illustrate the Shearing mechanism.

CONCLUSION

In conclusion, the assessment and experiment of the famous tea's picking end effector have shed important light on the performance of deviation tolerance. This study helps to optimize the tea harvesting process by evaluating the end effector's capacity to pluck tea leaves precisely and effectively. The outcomes highlight how crucial it is to choose an end effector that can adapt to differences in tea leaf size, shape, and location. The identification of end effectors that demonstrate high precision and dependability when plucking tea leaves, avoiding waste, and maximizing production, is made possible by the deviation tolerance performance evaluation. The experiment also clarifies how environmental variables like humidity and temperature affect how well the end effector functions. To create reliable and adaptive picking systems that can keep their efficacy under various tea manufacturing settings, it is essential to understand these factors.

REFERENCES

[1] L. Amoasii, E. Sanchez-Ortiz, T. Fujikawa, J. K. Elmquist, R. Bassel-Duby, and E. N. Olson, "NURR1 activation in skeletal muscle controls systemic energy homeostasis," Proc. Natl. Acad. Sci. U. S. A., 2019, doi: 10.1073/pnas.1902490116.

[2] R. C. Smith et al., "Effects of pioglitazone on metabolic abnormalities, psychopathology, and cognitive function in schizophrenic patients treated with antipsychotic medication: A randomized double-blind study," Schizophr. Res., 2013, doi: 10.1016/j.schres.2012.10.023.

[3] X. Hu et al., "A decrease in serum 1,5-anhydroglucitol levels is associated with the presence of a first-degree family history of diabetes in a Chinese population with normal glucose tolerance," Diabet. Med., 2018, doi: 10.1111/dme.13534.

[4] A. Maron-Katz et al., "O37. Individual Patterns of Abnormality in Resting-State Functional Connectivity Reveal Two Data-Driven PTSD Subgroups," Biol. Psychiatry, 2019, doi: 10.1016/j.biopsych.2019.03.302.

[5] F. Masciopinto et al., "Effects of long-term treatment with pioglitazone on cognition and glucose metabolism of PS1-KI, 3xTg-AD, and wild-type mice," Cell Death Dis., 2012, doi: 10.1038/cddis.2012.189.

[6] C. Caffarelli, F. Santamaria, A. Vottero, and S. Bernasconi, "Progress in Pediatrics in 2012: Choices in allergy, endocrinology, gastroenterology, hematology, infectious diseases, neurology, nutrition and respiratory tract illnesses," Italian Journal of Pediatrics. 2013. doi: 10.1186/1824-7288-39-26.

[7] A. Korzenev, A. Lebedev, and E. Abritalin, "P-790 - Neural correlates of frustration in depressed patients and healthy controls: an fMRI study," Eur. Psychiatry, 2012, doi: 10.1016/s0924-9338(12)74957-x.

[8] S. R.C. et al., "Effects of pioglitazone on metabolic abnormalities, psychopathology, and cognitive function in schizophrenic patients treated with antipsychotic medication: A randomized double-blind study," Schizophrenia Research. 2013.

[9] O. Iurova and L. Marchenkova, "Features of distal forearm fracture in persons 50 years old and older," Endocr. Abstr., 2018, doi: 10.1530/endoabs.56.p168.

[10] G. Liu, J. Zhou, and F. Sun, "Design and in-orbit verification of data storage system for nano-pico satellites," Harbin Gongye Daxue Xuebao/Journal Harbin Inst. Technol., 2018, doi: 10.11918/j.issn.0367-6234.201706176.

CHAPTER 3

OPTIMIZATION OF THE BLOCKING WHEEL-TYPE SCREW FERTILIZER DISTRIBUTOR'S STRUCTURE AND PERFORMANCE

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

A blocking wheel-type screw fertilizer distributor was developed to improve fertilization uniformity at low rotational speeds and control the amount of a distributor. The distributor variables were optimized using single factor and L9(34) orthogonal simulation experiments using EDEM software. Bench verification tests were conducted to assess distributor performance. The simulation tests showed a minimum coefficient of variation of fertilization uniformity (CVFU) of 19.27% for the structural parameter combination of inner diameter, pitch, outlet distance, and number of screw heads. The verification test showed similar CVFU trends and values. The performance test showed a maximum CVFU of 29.43% and a CVFS of 2.18%, meeting industry standards. This study is useful for researchers in precision fertilization and screw fertilizer distribution optimization.

KEYWORDS:

Fertilizer Distribution, Agricultural Machinery, Precision Farming, Mechanized Agriculture, Fertilizer Efficiency.

INTRODUCTION

Increased fertilizer use rates, cost savings, and farming efficiency can all be achieved through the use of mechanized precision fertilization. Researchers have created machines that use rotary encoders and the Global Positioning System (GPS) to measure the forward speed of the machines and adjust the fertilizer quantity rate to the forward speed in order to address the impact of variable forward speed on fertilization accuracy. Meng et al. and Jeong et al. implemented a map-based variable rate fertilizer application system to address the demands of the various fertilizer amounts induced by various soil fertilities. They employed GPS to determine the machine's position, and ground wheels to determine its forward speed. The fertilization rate would then be modified based on the forward speed, position data, and previously recorded prescription map.

Sensors were employed by Kim et al., Chen et al., and Cho et al. to gather data on crop growth status or soil organic matter to estimate the need for fertilizer. Following that, the fertilization rate was modified in accordance with the machine's forward speed and the fertilization requirements. Yuan et al. used a controller based on Advanced RISC Machines/Digital Signal Processor (ARM/DSP) to control the electric push rod to change the effective working length of the groove wheel fertilizer distributor and to control the speed of the direct-current (DC) motor to adjust the speed of the screw shaft in order to improve the fertilizer discharging precision of the fertilizer distributor. The research mentioned above focuses mostly on fertilizer distributor speed control and coordination with forward speed and other decision-making data. However, the machines' fundamental parts, the distributors, also had a big impact on how well the machines worked [1], [2].

To increase the effectiveness of fertilization, experts have recently kept coming up with new ideas and optimizing fertilizer distributor structure. For instance, researchers improved the structure of the groove wheel, fertilizer tongue, and fertilizer guidance devices to increase the stability and uniformity of the fertilizer distributor. However, the application of this type of distributor was severely constrained because it was only appropriate for granular fertilizers with good fluidity and dryness. The screw fertilizer distributor has drawn increased attention due to its strong adaptability to fertilizers with various fluidities. In order to address the issue of fertilizer discharge that was uneven, Nakesha et al. inserted a segment reflector and chose the screw diameter, the number of screw heads, and the number of ripples of the reflector to screw distributor. In order to assess the effectiveness of a double-level horizontal screw fertilizer distributor, Chen et al. used a variety of granular and powder fertilizers. This confirmed that the screw fertilizer distributor had high fertilization stability and was adaptable to fertilizers with various fluidities [3].

Cao determined the ideal screw structure parameters and operating speed by optimizing the structural characteristics of the screw fertilizer distributor and analyzing the impact of screw speed on fertilizer distributing performance by DEM and bench test. Using theoretical analysis, numerical simulation, and tests, Dong investigated the vertical screw fertilizer distributor's movement law of fertilizer, identified its ideal structural and operating parameters, and demonstrated that the device had good fertilization stability and uniform rotating speed. The aforementioned study focused in particular on the flexibility of the design and operational characteristics of the screw fertilizer distributor for various fertilizers. The analysis of how legislation and mechanism affect the design and operational characteristics of the screw fertilizer distributor and the uniformity of fertilization was insufficient. It is challenging to satisfy the needs of precision fertilizer application since the amount of fertilizer distributed by conventional screw fertilizer distributors can only be changed by the screw shaft rotation speed, and the uniformity of fertilizer discharge is poor when the rotation speed is low [4].

This study has constructed a blocking wheeltype screw fertilizer distributor to address the aforementioned issues:

i. Using EDEM software, single factor and L9(34) orthogonal simulation experiments at a slow speed of 20 r/min were used to improve the structural characteristics of the distributor.

ii. To confirm the simulation results, bench verification tests were conducted in the identical circumstances as the simulation testing.

iii. Bench performance tests were used to gauge the distributor's performance. This study is a helpful resource for the development of precision fertilization technology as well as the optimization of the screw fertilizer distributor [5].

Materials and Methods

i. Structural Design

Figure 1 depicts the structure of the blocking wheel-type screw fertilizer distributor. It had a pyramidal feeding entrance, a spiral blocking wheel, a screw fertilizer transportation axis, a sleeve of screws, and a fertilizer outlet. In the diagram, D stands for the screw blade's outer diameter, d for its inner diameter, Pt for the pitch, b for the screw blade's average thickness, K for the spiral blocking wheel opening width, and S for the outlet distance (short for the distance between the end of the screw blade and outlet) [6].

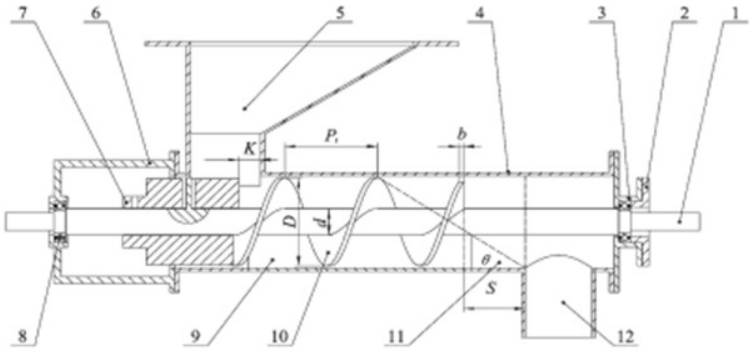


Figure 1: The blocking wheel-type screw fertilizer distributor's structure. Screw shaft 1 Bearing cover 2. 3. The sleeve's end cover, 4. A screw sleeve 5. Pyramidal inlet feeding 6. The nut seat Spiral blocking wheel, number 7.8. Holding 9. A cleaning outlet for fertilizer and its cover 10. Screwdriver 11. The buffer zone for fertilizers Fertilizer outlet 12. Note: D stands for the screw blade's outer and inner diameters in millimeters; Pt for the pitch; b for the screw blade's average thickness; K for the spiral blocking wheel opening width; and S for the outlet distance [7].

ii. Operation Principle

When in use, the feeding entrance allows the fertilizer particles to fill the first screw section under the force of their own gravity. Fertilizers in the screw's beginning section are pushed to the screw's end by the screw blade's action as the screw shaft rotates. Then, through the fertilizer buffer zone between the screw blade's tip and the fertilizer outlet, they are released through the fertilizer outlet. As opposed to the current screw fertilizer distributor, this one has a buffer zone between the end of the screw blade and the fertilizer outlet. This allows the fertilizer that has been transported to the distributor's end to be slowly released from the outlet, improving fertilization uniformity. The screw fertilizer distributor's FAPL (fertilizer amount per lap) can be modified using the blocking wheel. Because of the low goal fertilization rate, it is possible to improve the fertilizer distributor's uniformity by lowering the amount of fertilizer used every lap and raising the screw shaft's rotational speed [8], [9].

iii. Force Analysis of Fertilizer Particles

Gravity G, the friction force F_w produced by the fertilizer distributor's outer shell wall, and the force of the screw blade on the fertilizer particles all act together to affect the fertilizer particles inside the fertilizer distributor. Figure 2 depicts the force exerted by the screw blade on fertilizer particles as well as the normal pressure F_N and tangential friction force F_s. Their combined force equals F. An axial force P1 and a circumferential force P_2 can be created from the force F. The fertilizer moves axially toward the outlet under the influence of force P1, while the fertilizer particles travel radially under the influence of force P_2. The fertilizer particles slide axially in the fertilizer distributor despite this movement being resisted by gravity G and friction force F_w.

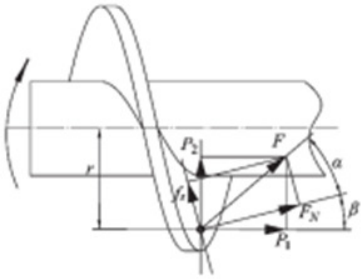


Figure 2: Illustrate the Force of screw blade on fertilizer particles.

According to Figure 2, the force F is decomposed by Equation (1):

$$\begin{cases} P_1 = F\cos(\alpha+\beta) \\ P_2 = F\sin(\alpha+\beta) \\ \alpha = \tan^{-1}\mu \\ \beta = \tan^{-1}\frac{P_t}{2\pi r} \end{cases}$$

where F is the total force of screw blade acting on fertilizer particles, N; P_1 is the axial component of F, N; P_2 is the circumferential component of F, N; α is the friction angle between blade and fertilizer, (°); β is the lift angle of screw blade, μ is the friction coefficient between fertilizer and screw blade; P_t is the pitch screw blade, mm; r is the distance between particles and axis of screw shaft, mm [10].

DISCUSSION

Methods of DEM Simulation Tests

This study examined the effects of the parameters (inner diameter of the screw blade d, pitch Pt, number of screw heads Z, outlet distance S, and the opening width of the locking wheel K) on FAPL and CVFU while keeping the outer diameter of the screw blade fixed at D = 45 mm. The low screw shaft rotation speed used for all simulations was 20 r/min.

Simulation Model and Parameter Setting

This work adopted the "Hertz-Mindlin (no slip)" contact model to mimic the composite fertilizer particles because studies have shown that the particles of compound fertilizer are typically spherical or ellipsoidal discrete parts, with high sphericity and no adhesion between the particles. In accordance with previous research, the average particle size of fertilizer particles (d_s) was set at 3.3 mm, with the creation technique of the particle size range being "random" and the setting range being 0.75-1.25. The diameter of the produced particles was then between 2.475- and 4.125-mm. Table 1 displays the other simulation parameters.

Table 1: Calculation of CVFU in Simulation Tests.

Parameters	Value
Poisson's ratio of fertilizer	0.28
Density of fertilizer (kg/m^3)	1511
Shear modulus of fertilizer (Pa)	1×10^7
Poisson's ratio of ABS	0.394
Density of ABS (kg/m^3)	1060
Shear modulus of ABS (Pa)	8.9×10^8
Coefficient of Restitution between fertilizers	0.35
Coefficient of Static Friction between fertilizers	0.4774
Coefficient of Rolling friction between fertilizers	0.21
Coefficient of restitution between fertilizer and ABS	0.359
Coefficient of Static Friction between fertilizer and ABS	0.1962
Coefficient of restitution between fertilizer and ABS	0.15

The simulation test in this study was run using the following methodology in order to increase simulation speed. In the preliminary phase, a 3D model of the fertilizer distributor was created in the software Solidworks with the required blocking wheel width K. The 3D model was imported into EDEM as part of the simulation model setup process, and the screw shaft's rotation speed was adjusted at 20 r/min. Other simulation parameters were established using Table 1 as a guide. Then, a particle factory was constructed to produce 1 kg of fertilizer particles in 1 second, which were then added to the fertilizer box. After the particles in the fertilizer box had stabilized, the fertilizer screw was turned.

The FAPL of the screw fertilizer distributor could be computed after the simulation was complete. First, a total mass sensor for the fertilizer that was still present was constructed (see Figure 3). The FAPL could then be determined using Equation (3) after the fertilizer has been dispersed steadily throughout a timeline with two different times and two total mass values. The screw fertilizer distributor's CVFU could be estimated using the formulas below. First, as illustrated in Figure 3, a cylindrical mass sensor for the fertilizers was constructed near the fertilizer output. Second, the sensor measured the mass of the fertilizer emitted from the fertilizer outlet every 0.2 seconds. Thirdly, when the fertilizer had been delivered steadily, a continuous 6 s with 30 mass values could be chosen, and the CVFU could be calculated using Equation (4). This testing procedure simulated the distributor crossing a 3 m length of discharge while moving forward at a constant speed of 0.5 m/s.

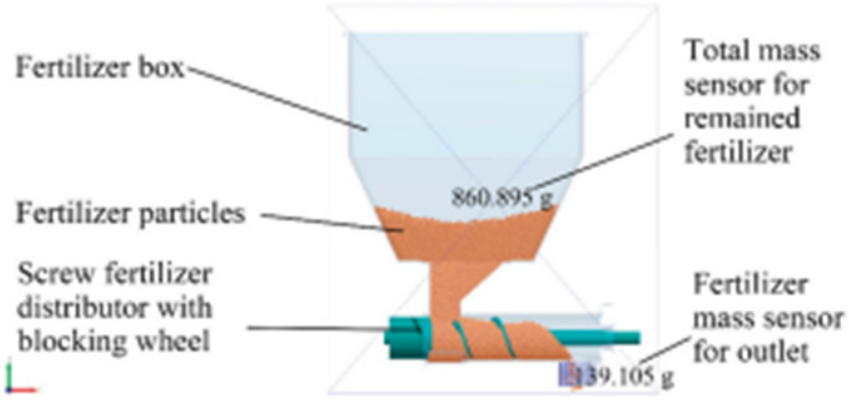


Figure 3: Illustrate the Simulation Model and Mass Sensors.

Single Factor Tests Method

The screw pitch and outside diameter of the horizontal screw conveyor had the following relationship in accordance with the design specifications:

$$P_t = k \cdot D$$

where P_t is the pitch, mm; D is the outer diameter of screw blade, mm; k is the pitch coefficient, usually k is 0.5-1. Therefore the range of P_t was 22.5-45 mm calculated by above equation. AS a result, the pitch was set to 25, 35 and 45 mm, respectively. To make sure the fertilizer particles are completely gathered in the fertilizer distributor when it is static, the outlet distance S should be calculated using

$$\begin{cases} S = r - P_t \\ r = \frac{D}{\sin\theta} \end{cases}$$

where S is the outlet distance, mm; P_t is the pitch; r is the stacking radius, mm; D is the outer diameter of screw blade, mm; θ is the fertilizer stacking angle.

CONCLUSION

In conclusion, the blocking wheel-type screw fertilizer distributor's structural optimization and performance assessment have improved the effectiveness and efficiency of fertilizer distribution in agricultural applications. The distributor's structural design has been improved through the optimization process, which has increased dependability, decreased energy usage, and improved overall performance. The optimized distributor achieves more precise and uniform fertilizer distribution, avoiding waste and maximizing crop nutrient absorption, by taking into account elements like material selection, screw design, and blocking wheel mechanism. The blocking wheel-type screw fertilizer distributor's performance study has shed important light on its operational capabilities. The evaluation shows the performance of the distributor in distributing fertilizers to the designated locations, encouraging optimal crop development and output by examining characteristics including distribution uniformity, spreading width, and accuracy. These developments in structural optimization and performance assessment have a big impact on farming methods. Improved fertilizer delivery systems that guarantee effective nitrogen delivery to crops, resulting in increased productivity and decreased environmental impact, might be advantageous to farmers. The optimized distributor also provides the opportunity for cost reduction and resource optimization in the agricultural industry.

REFERENCES

[1] W. Yang, L. Fang, X. Luo, H. Li, Y. Ye, and Z. Liang, “Experimental study of the effects of discharge port parameters on the fertilizing performance for fertilizer distribution apparatus with screw,” Nongye Gongcheng Xuebao/Transactions Chinese Soc. Agric. Eng., 2020, doi: 10.11975/j.issn.1002-6819.2020.17.001.

[2] X. Lei, M. Li, L. Zhang, and W. Ren, “Design and experiment of horizontal pneumatic screw combination adjustable quantitative fertilizer feeding device for granular fertilizer,” Nongye Gongcheng Xuebao/Transactions Chinese Soc. Agric. Eng., 2018, doi: 10.11975/j.issn.1002-6819.2018.19.002.

[3] S. P. Senda, R. Handogo, A. Roesyadi, and W. Sumaryono, "Mixing Urea and Zeolite for Slow Release Fertilizer using Orbiting Screw Mixer," IPTEK J. Technol. Sci., 2009, doi: 10.12962/j20882033.v20i4.83.

[4] G. Wei, B. Qi, W. Jiao, S. Shi, and S. Jian, "Design and Experiment of Mechanical Forced Fertilizing Device for Paddy Field," Nongye Jixie Xuebao/Transactions Chinese Soc. Agric. Mach., 2020, doi: 10.6041/j.issn.1000-1298.2020.S1.018.

[5] X. Chen et al., "Design and experiment of fertilizer distribution apparatus with double-level screws," Nongye Gongcheng Xuebao/Transactions Chinese Soc. Agric. Eng., 2015, doi: 10.3969/j.issn.1002-6819.2015.03.002.

[6] S. Cahyono and A. Prasetyo, "Design Omnidirectional Movement Screw Blade of An Unmanned Mini Tiller," Mek. Maj. Ilm. Mek., 2020, doi: 10.20961/mekanika.v19i1.40355.

[7] H. Ahmad Saffian, K. Abdan, M. Ali Hassan, and A. Ibrahim, "Characterization, morphology, and biodegradation of bioplastic fertilizer (BpF) composites made of poly(Butylene succinate) blended with oil palm biomass and fertilizer," Polym. Compos., 2017, doi: 10.1002/pc.23849.

[8] B. R. Birajdar, S. V. Kulkarni, and M. B. Awate, "Design and production of fertilizer spreading mechanism for sugarcane," in Techno-Societal 2018 - Proceedings of the 2nd International Conference on Advanced Technologies for Societal Applications, 2020. doi: 10.1007/978-3-030-16848-3_37.

[9] M. A. Hossen, M. G. K. Bhuiyan, M. M. Rahman, M. K. Zaman, M. M. Islam, and M. A. Rahman, "Development of mixed fertilizer deep placement technology into soil simultaneously with mechanical rice seedling transplanting," J. Sci. Technol. Environ. Informatics, 2020, doi: 10.18801/jstei.090220.66.

[10] T. Gienau, U. Brüß, M. Kraume, and S. Rosenberger, "Nutrient recovery from anaerobic sludge by membrane filtration: pilot tests at a 2.5 MWe biogas plant," Int. J. Recycl. Org. Waste Agric., 2018, doi: 10.1007/s40093-018-0218-6.

CHAPTER 4

AN OVERVIEW OF THE AGRICULTURAL MECHANIZATION

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

Mechanization is crucial for increasing production, efficiency, and sustainability in the agricultural sector. It reduces manual labor, boosts produce output, and improves farm management. Mechanization includes tractors, harvesters, irrigation systems, precision agriculture instruments, and automated systems for various farming tasks. It improves crop yields, reduces post-harvest losses, and maximizes resource use. It encourages sustainable practices like conservation tillage and precision farming, and addresses labor shortages in rural regions. However, access to machinery remains a major barrier, especially for smallholder farmers and those in underdeveloped countries. High costs of purchasing, using, and maintaining technology may prevent widespread adoption. Competent training and technical assistance are necessary for efficient and secure machinery use. Policymakers, researchers, and industry stakeholders must collaborate to support farmers' access to inexpensive mechanized technology, offer training and capacity-building initiatives, and facilitate financing. The efficiency and efficacy of agricultural mechanization can be further enhanced by embracing innovation and incorporating digital technologies.

KEYWORDS:

Farm Machinery, Technology, Automation, Precision Agriculture, Agricultural Productivity, Sustainable Farming.

INTRODUCTION

It is commonly accepted that agriculture in Africa will need to change by sustainably intensifying production if it is to accomplish its growth and poverty reduction goals. Pretty et al. In response to this demand, initiatives by African governments and the donor community, such as the Comprehensive African Agriculture Development Programme (CAADP), have concentrated on boosting investments and enhancing strategy implementation. In order to reach a goal of 6% yearly growth, African states pledged to allocate 10% of their national budgets to the agricultural sector in the Maputo Declaration of 2003. The CAADP platform, along with numerous politicians and academics, acknowledges the significance of agricultural mechanization in fostering the intensification that may be necessary to transform African agriculture and result in more generalized growth and development outcomes.

Although there are varying estimates of the precise levels of automation, people constitute the primary source of power for agricultural output in Sub-Saharan Africa (SSA), where mechanization levels are comparable to those in Asia and Latin America. A few locations in Sub-Saharan Africa have recently experienced a sustained adoption of agricultural mechanization, which includes using engine-powered equipment and animal traction. The majority of these areas are huge commercial farms. While African governments made significant efforts to mechanize agriculture in previous decades, these efforts mostly failed due

to a lack of farmer demand (Pingali et al 1987). Farm electricity availability decreased in Africa during the 1980s and 1990s as a result of the failure of state-led mechanization, despite rising quickly in other emerging regions [1].

Nevertheless, a fresh focus on mechanization may have resulted from the need for mechanization that may have started to arise in some regions of Africa in recent years. Wherever there has been a desire for mechanization, private supply chains have frequently developed around it, offering tools and machinery as well as hiring and repair services. Private supply chains are not always fully developed, despite the fact that they may be quite responsive to farmers' demand. This is frequently because of market failures that need to be addressed through additional support, such as crowding out/distortion brought on by government policies and programs, high fixed costs, or all of the above. This stresses how crucial it is to provide a suitable and encouraging governmental framework in order to allow private supply channels to successfully fulfill demand. However, there is still a dearth of study and understanding regarding the need for mechanization, the level of mechanization as it exists today, and its consequences on labor, productivity, and other outcomes [2].

The majority of the information for this article will come from recent research on the demand for mechanization that is on the rise, the amount to which private and public supply chains have developed to accommodate that demand, and the impact of governmental regulations on the results of mechanization. The work of Pingali and Binswanger, who advanced the Bosreupian notion of mechanization as part of the intensification process, forms the foundation of a large portion of the literature discussed in the study. This research evaluates the evidence that is currently available to characterize and contrast the various supply chains for mechanization in Africa, with a focus on the uptake of engine-powered mechanization among small, medium, and large scale farmers1. As mechanization has not been well covered by national-level data and similar surveys have not been carried out in other African nations, a large portion of this evidence comes from a mechanization-focused study done by IFPRI/SARI in Northern Ghana.

While mechanization trends show significant spatial variation, this paper finds that there does appear to be a case of emerging private demand for mechanization among farmers of various sizes, even though there is not enough data to attempt to address empirical questions about mechanization. Where there is a need, farmer-to-farmer service delivery seems to be the most efficient way to fill it; nevertheless, government-directed and subsidized service delivery may erode the private sector's comparative advantage in offering mechanized services. However, in order to overcome the obstacles to a more comprehensive agricultural transformation, the study offers a variety of helpful roles that governments might play in encouraging mechanization. These responsibilities include the supply of public goods like education, research, and information, as well as advantageous trade policies, the development of infrastructure, and the facilitation of credit access [3], [4].

We provide a set of definitions of mechanization that are taken from the literature in the section that follows the definitions are presented in light of the function that mechanization plays in the processes of agricultural intensification. The demand side of mechanization is next covered in Section 3, where we go over the primary elements influencing the desire for mechanization among various types of farmers. We also make an effort to describe the patterns of demand for mechanization throughout Africa. In coming chapters, we will concentrate on the supply side of mechanization, taking into account the supply of mechanization as a chain comprising

numerous actors, such as manufacturers, importers, and distributors, as well as mechanization service providers and machinery maintenance providers [5], [6].

Definitions and Concepts

i. Definitions of Mechanization

Mechanization is described by the FAO as "the use of tools, implements, and machinery to achieve agricultural production". All of these can be run manually, by an animal, or by an engine that runs on fossil fuels or electricity. Essentially, agricultural mechanization refers to technical advancement in which non-human sources of power are used to carry out agricultural tasks. Mechanized agricultural operations can be divided into those that require a lot of power and control. Mechanization of labor-intensive agricultural processes, such as land preparation, threshing, grinding, and milling, is characterized by the replacement of human and animal labor with non-human sources of energy. In contrast, mechanized control intensive processes like planting, weeding, winnowing, and fruit harvesting demand more energy as well as a higher level of human judgment and mental effort . One way to think of grain harvesting is as a power- and control-intensive process. Additionally, some literature divides mobile tasks, such as harvesting, weeding, and plowing, from stationary operations like milling, water lifting, and threshing. Understanding the need for automation requires making distinctions between power and control-intensive tasks as well as stationary and mobile operations. Mechanized operations frequently follow specific sequential patterns, as will be demonstrated in following sections. Irrigation and transportation powered by engines are two tasks that are occasionally categorized as mechanization. Except in circumstances when they enhance the mechanization of other agricultural processes, we generally ignore them in this article [7].

ii. Mechanization and Agricultural Intensification

The process of agricultural intensification includes mechanization. Boserup (1965) and Ruthenberg (1980) defined agricultural intensification as the increased application of labor and other inputs per unit of land intensified use of inputs and more frequent cropping of land through reducing fallow periods intensified use of land. This definition is based on the perspectives of long-term evolution of farming systems and agricultural technology. Agricultural extensification, on the other hand, is the intensified use of land that frequently results in the expansion of cropping areas by reducing forest or fallow land and is referred to as agricultural intensification in agricultural economics literature that does not focus on the long-term evolution of farming systems.

Boserup (1965), and later further formalized and tested by Pingali et al. (1987), Binswanger and McIntire (1987), and McIntire (1992)), links agricultural intensification with increased demand for agricultural products by treating farming system evolution as well as the technologies used under various farming systems as endogenous processes. Population expansion and better market access, including both local and foreign market access which expands agricultural demand beyond farmers' own subsistence needs, are the causes of this rising demand [8].

In addition to using more agricultural inputs, intensification in agricultural output is a process of changes in agricultural technology in response to the rise in demand for agricultural products. The technology that enables the intensification of agricultural productivity heavily

relies on mechanization. Mechanization will be used when more land has to be put under cultivation to satisfy rising market demand or when existing land needs to be farmed more intensively, requiring more manpower per unit of land. Therefore, another important factor affecting mechanization is the dynamic interaction between land and labor (or changes in the land-labor ratio in particular), as part of the intensification process. Thus, the induced technical change paradigm created by Hayami and Ruttan (1970, 1985) can also be used to explain mechanization, especially the demand for it.

A model of induced technical change was developed in the early 1970s by Hayami and Ruttan (1970, 1985) and Binswnger and Ruttan (1978), in which the creation and use of new technology are endogenous to the economic system (Ruttan 2002). With the use of this framework, we may evaluate how rapidly mechanization is becoming more and more in demand. As a result of the relative scarcity of land or labor endowment being reflected in the change in their relative prices, the induced technical change model emphasizes agricultural technology innovation and adoption as a continuous sequence often biased toward saving the limiting factor land or labor (Hayami and Ruttan 1970). Alternative agricultural technologies are created in this model (and embraced by farmers) to make it easier to replace relatively abundant (cheap) inputs with relatively scarce (expensive) factors. When compared to biological and chemical technology, which is intended to save land, mechanical technology is "labor saving" since it can replace labor with power and machines. The adoption of labor-saving technology by farmers is not necessarily motivated by an incentive to improve land productivity, as is the case with the adoption of biological technology, as changes in land and labor productivity are comparatively independent (Griliches 1968) [9].

Mechanization may be more important in the processes of agricultural intensification in Africa than it was in the processes of agricultural intensification seen in the Asian Green Revolution (GR), given the relatively high land-to-labor ratio on agricultural endowments in many African countries. In the majority of Asian nations during the GR, there were limited rural non-farm employment options and a low land-to-labor ratio. Land is more abundant in several African nations than it is in many Asian nations that experienced the Green Revolution, including portions of Ghana, Nigeria, Senegal, and Zambia (Nin-Pratt and McBride 2014). The urbanization process has also accelerated in several African nations recently, partly because many of them export natural resources and partly because the service sector makes up a considerably greater portion of their economy than it did in most Asian nations at comparable levels of per capita income.

As a result of these structural features of some African economies, "consumption cities" are created, where urbanization takes place without industry. Even though agricultural land productivity, as measured by yield, is still significantly lower in most African countries than in the post-GR Asian countries, migration to the urban areas as well as increased employment opportunities in non-farm services in the rural areas could put pressure on rural wages. Therefore, in some African countries, the need for labor-saving technologies may become a prerequisite for continued agricultural intensification, at least in regions with better market access and higher opportunity costs for rural labor. Therefore, unless such labor constraints can be overcome through mechanization, it is possible that the lack of labor-saving technology limits the potential returns to certain types of land-saving technology, such as improved seeds, and application of fertilizers and pesticides [10].

DISCUSSION

Demand for Mechanization

i. Sufficient Demand as a Precondition for Successful Mechanization

Mechanization is typically in demand when farmers find it to be more affordable to use it than other accessible solutions. So, before implementing any legislative changes to encourage mechanization, it is necessary to verify that there is in fact a significant demand. Almost all of the 30 mechanization programs in Africa between 1945 and 1987 that reviewed failed to take into account the lack of demand among farmers. This is considered to be one of the main reasons why the governments in these nations introduced tractors at an inopportune time. Under these initiatives, tractor hiring services swiftly fell apart due to a lack of demand, and many equipment were left unused, dismantled, or abandoned (Pingali et al. 1987).

It is reasonable to assert that encouraging mechanization in the absence of sufficient demand has a tendency to be socially undesirable and may also have negative equity impacts. As Pingali (2007) contends, increased tractor use by medium and large-scale farmers is likely to displace tenant farmers or hired labor provided by landless farmers where the capacity and demand for aggregate land expansion is constrained. There is not much proof that this impact exists in Africa, despite it having been found in South Asia (Lockwood et al 1983; Jabbar et al 1983; Singh et al 2013). Displacement and unfavorable equity consequences continue to be significant future issues, despite the fact that they do not appear to be as substantial as anticipated by a wave of cross-continental ILO research in the early 1970s (Mrema et al 2008).

ii. Components of Mechanization Demand

The demand for mechanized agricultural operations frequently rises progressively, as was previously indicated and will be further described below. The sequences of demand for mechanization are influenced by the same factors that determine agricultural intensification. Additionally, these demand sequences are impacted by various agro-ecological circumstances, the accessibility of technologies, and the capacity to fully utilize them.

iii. Farm Size and Mechanization

Tractors can be crucial for increasing the total area that large farms cultivate in a society where there are both large and small farmers. For large farms, hired labor accounts for a significant amount of their production costs. Mechanization has become a more alluring technology for such farms due to the economies of scale associated with a large machine like a tractor. Due to this, the initial tractor owners in the majority of emerging nations are usually larger farmers who also offer hiring services to non-owners when it helps them make the best use of their tractors. These patterns have been seen across Asia. According to tractor owners typically own four times as much land in Punjab, India, as do tractor hirers. In Thailand, tractor hirers similarly owned far more land than non-hirers (23 acres as opposed to 9 acres). Although a sizable portion of smallholders in Asia have adopted mechanization as will be discussed later, cases from Asia demonstrate that mechanization is frequently fueled by large farm sizes and allows farmers to further increase their landholdings, though this is not a requirement for mechanization to be profitable.

It appears that mechanization is largely following this pattern throughout Africa. Large farm sizes have long been a feature of North African agriculture. According to, medium-scale farmers (5-100 ha) cultivate the biggest portion of the country's cropland in Ghana and Zambia, two Sub-Saharan examples of countries with land dynamics conducive to mechanization. Over half of tractor owners identified land development as the main reason for their investment in the 2013 IFPRI/SARI survey of medium-to-large farmers in Northern Ghana. Although at a far slower rate than tractor owners, farmers who used tractor services extended their land more than farmers who did not. Similar to how land expansion appears to be a major factor in the adoption of mechanization in Southern Nigeria, where it is primarily used to increase the input area for input-intensive rice cultivation, it does not appear to apply in the North, where it is used to replace household labor on small, intensively-cropped farms and enable the pursuit of off-farm income generation. Mechanization is generally more likely to be possible if there are many households with large farms and the possibility of expanding the area, yet it is obvious that mechanization may still be adopted profitably even in the absence of these circumstances.

iv. Labor Saving Effects of the Mechanization of Certain Operations

Mechanized plows result in small reductions in the labor needed for weeding and harvesting but much less labor is needed for preparing the ground (Pingali et al 1987). Even smaller farmers start to request mechanization technology when labor costs start to grow in areas where hired labor accounts for a sizable portion of production costs in order to lower their labor and overall production costs. For instance, according to information from the GLSS 5 (Ghana Living Standards Survey 5) for the years 2005–2006, hired labor accounts for an average of 40% of paid input expenses in Ghana while fertilizers account for 28% (Figure 1) . Despite having lower per capita incomes than the south of Ghana, this cost share is even higher in the relatively land-rich northern regions of that country. In the Brong Ahafo and Northern regions of Ghana, two of the more mechanized in terms of land preparation, the share of hired labor costs is around 50%. Interestingly, in GLSS 6 (Figure 2), expenditures on hired labor and fertilizer both make up a smaller proportion of overall production costs than do expenditures on herbicides, which can also be seen as a labor-saving technique because they prevent weed growth. Although it is unclear to what kind of equipment this refers, the share of expenditure on hired equipment increased dramatically in the Northern and Upper West regions, reaching 14 and 17 percent, respectively. This may be an indication of mechanization adoption tendencies in Northern Ghana at the time.

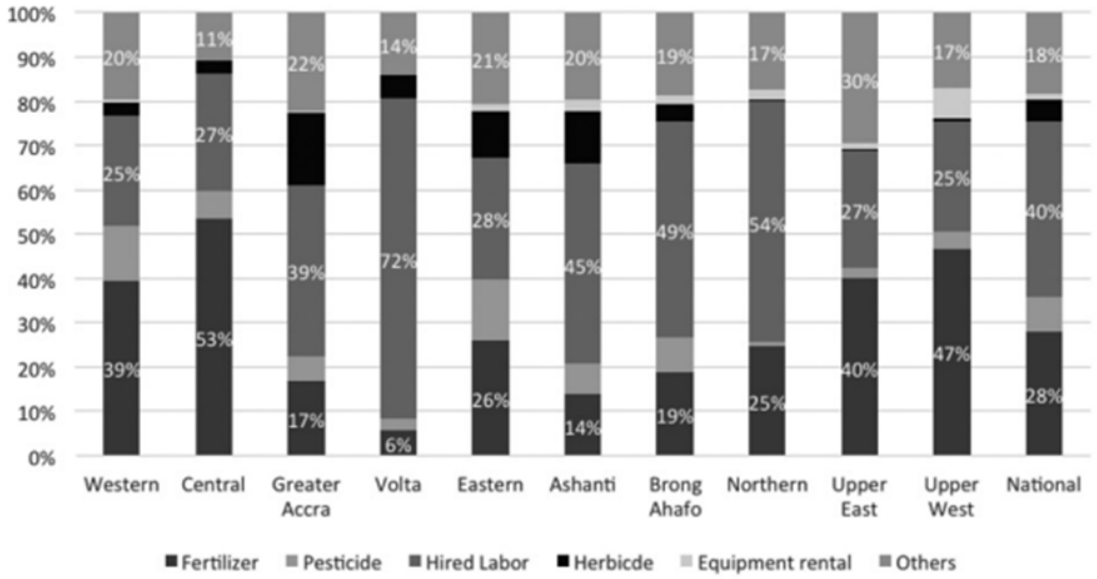


Figure 1: Shares of Input Costs by Region, 2005/06.

While less labor is needed for this activity because to robotic land preparation, this does not mean that there will be a decrease in the demand for labor as a whole. When compared to fields plowed using draught animals, Panin (1995) finds that tractor use among the surveyed farmers actually increased labor requirements. This is because tractor plowing reduced the labor input for plowing but increased the required labor for weeding, harvesting, and threshing. Tractor-based mechanization typically enables farmers to save labor for weeding and land preparation in areas where draught animals are not an option including many parts of West Africa, as weeds typically regrow more slowly in fields plowed by tractors. In this instance, mechanization probably boosts farmers' overall profitability. Even at small-scale farms in several Asian nations, mechanization has recently become very popular among smallholders due to its labor-saving advantages. This is frequently illustrated using Bangladesh and other South Asian nations as prime examples.

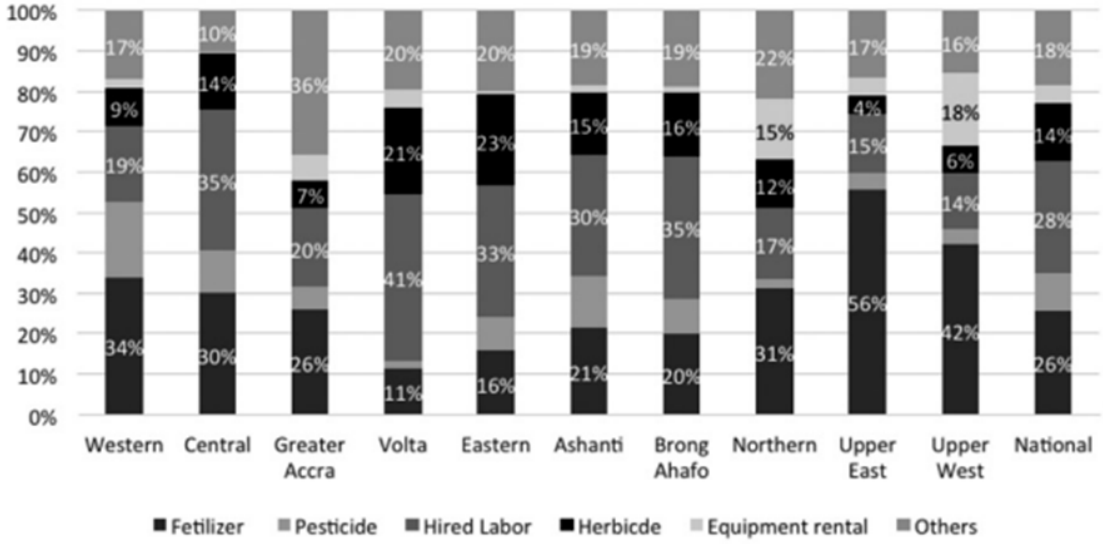


Figure 2: Shares of Input Costs by Region, 2012/13.

The governments of several African nations sometimes exploit the reduction of the labor-intensive nature of agriculture as justification for their intervention in favor of mechanization. This laboriousness is inherent to farming. However, it appears that this toil has grown more significant in explaining the opportunity cost of labor, especially for young farmers. Numerous arduous agricultural tasks are frequently performed by women and children. It's well knowledge that the drudgery of manual agricultural labor can turn off young people from farming and lead them to look for potentially less productive off-farm employment (Mrema et al 2008). Although this idea seems reasonable, there is still a dearth of empirical support for it.

CONCLUSION

In conclusion, methods used in agriculture have a critical role in advancing agricultural intensification. Farmers can boost output, boost efficiency, and best utilize resources thanks to mechanisms like machinery, equipment, and automated systems. Mechanization can increase crop yields, lower labor costs, and minimize losses in a variety of farming processes, including planting, irrigation, harvesting, and post-harvest processing. Inputs like fertilizer and insecticides can be applied precisely, resulting in the most efficient use of resources and long-term sustainability of the environment. But for methods to successfully intensify agriculture, several different elements must be carefully taken into account. For adoption to be widely used, farmers must have access to the right equipment, it must be affordable, and they must receive training. To maximize its advantages, mechanization must also be combined with other factors, including as agronomic methods, technology integration, and market access. Addressing issues and promoting the sustainable use of mechanisms in agricultural intensification should be priorities. This entails making sure programs are affordable, offering technical assistance, and promoting information sharing and capacity-building initiatives. To build an environment that encourages the use and adaptation of mechanized technologies, policymakers, researchers, and industry stakeholders must work together.

REFERENCES

[1] T. Daum and R. Birner, “Agricultural mechanization in Africa: Myths, realities and an emerging research agenda,” Global Food Security. 2020. doi: 10.1016/j.gfs.2020.100393.

[2] R. Devkota et al., “Responsible agricultural mechanization innovation for the sustainable development of Nepal’s hillside farming system,” Sustain., 2020, doi: 10.3390/SU12010374.

[3] H. Takeshima, P. L. Hatzenbuehler, and H. O. Edeh, “Effects of agricultural mechanization on economies of scope in crop production in Nigeria,” Agric. Syst., 2020, doi: 10.1016/j.agsy.2019.102691.

[4] T. Daum and R. Birner, “The neglected governance challenges of agricultural mechanisation in Africa – insights from Ghana,” Food Secur., 2017, doi: 10.1007/s12571-017-0716-9.

[5] M. Emami, M. Almassi, H. Bakhoda, and I. kalantari, “Agricultural mechanization, a key to food security in developing countries: Strategy formulating for Iran,” Agric. Food Secur., 2018, doi: 10.1186/s40066-018-0176-2.

[6] W. Li, X. Wei, R. Zhu, and K. Guo, "Study on factors affecting the agricultural mechanization level in China based on structural equation modeling," Sustain., 2019, doi: 10.3390/su11010051.

[7] D. Albiero, R. S. Xavier, A. P. Garcia, A. R. Marques, and R. L. Rodrigues, "The technological level of agricultural mechanization in the State of Ceará, Brazil," Eng. Agric., 2019, doi: 10.1590/1809-4430-Eng.Agric.v39n1p133-138/2019.

[8] A. Sarkar, "Agricultural Mechanization in India: A Study on the Ownership and Investment in Farm Machinery by Cultivator Households across Agro-ecological Regions," Millenn. Asia, 2020, doi: 10.1177/0976399620925440.

[9] Y. Minli, L. Minzan, and L. Xiwen, "50 Years of agricultural mechanization in China," AMA, Agric. Mech. Asia, Africa Lat. Am., 2020.

[10] R. O. Akinbamowo, "A review of government policy on agricultural mechanisation in Nigeria," J. Agric. Ext. Rural Dev., 2013.

CHAPTER 5

AN OVERVIEW OF THE FACTORS INFLUENCING THE DEMAND FOR AGRICULTURAL MECHANIZATION

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

Complementary technologies are essential for improving agricultural productivity, sustainability, and revenue production in Africa. These technologies include mechanization, precise farming, digital platforms, better seeds, fertilizers, and market access. By implementing these technologies, farmers can boost agricultural output, maximize resource use, and enhance crop quality, leading to increased incomes and quality of life, particularly for smallholder farmers. However, strong mechanized supply networks are crucial for the effective application of complementary technologies in Africa. These networks ensure the availability, affordability, and accessibility of mechanized tools, spare parts, maintenance services, and expert assistance. To make Africa's supply chains more mechanized, investments and encouraging policies are needed, including promoting local machinery manufacturing, easing financing access, implementing training and capacity-building programs, and fostering private sector involvement. Complementary technologies have significant income-generating potential in Africa, but addressing issues of affordability, knowledge transfer, and infrastructure is crucial for their full potential.

KEYWORDS:

Telecommunication Systems, Electromagnetic Interference, Spectrum Allocation, Communication Infrastructure, RFI Deployment.

INTRODUCTION

Agricultural mechanization has played a pivotal role in transforming traditional farming practices into efficient and productive systems, ensuring food security and economic prosperity for societies around the world. Mechanized technologies, such as tractors, power tillers, combine harvesters, and other specialized equipment, have significantly enhanced the capacity of farmers to carry out various agricultural tasks, reducing labor requirements and increasing overall productivity. As the global population continues to grow, and with increasing pressure to meet the demands of a rapidly changing agricultural landscape, understanding the factors that influence the demand for agricultural mechanization becomes of paramount importance. This study aims to delve into the multifaceted aspects that drive the adoption and demand for agricultural mechanization. It acknowledges that the returns from mechanization, and subsequently the need for it, are intricately linked to several interdependent factors, including the prices and accessibility of complementing non-labor inputs.

Recognizing this intricate relationship, the study analyzes the influence of these factors on the adoption of mechanized technologies, thereby shedding light on the broader dynamics of agricultural transformation. Boserup's pioneering work has suggested that the intensification process, involving land-saving technologies like chemical fertilizers, invariably calls for more

labor, necessitating a greater need for mechanization. This hypothesis sets the stage for exploring the connection between mechanization and the utilization of complementary technologies, particularly chemical fertilizers and herbicides, in different agricultural contexts. Notably, the study observes how the availability and adoption of such technologies can impact the demand for mechanization, particularly in regions like South Asia and Northern Ghana, where mechanization has been found to be associated with increased fertilizer and herbicide use. Moreover, as the study delves into the West African rice irrigation systems, it unravels a compelling illustration of how the accessibility of auxiliary technologies plays a crucial role in the need for mechanization. Examining the relationships between mechanization, the profitability of irrigated rice farming, and the emergence of complementary technologies like seeds, fertilizer chemicals, land leasing markets, and private milling, the study establishes the significance of mechanization as a pivotal driver for agricultural transformation in such contexts. In the pursuit of comprehending the utilization and income generation potential of mechanized equipment, this study delves into various service-providing models. The profitability of service provision is a vital factor influencing the demand for mechanization among medium to large farmers. By examining the experiences of tractor owners and their profitable engagement in leasing mechanization services, the study highlights how this aspect further influences the adoption of mechanized technologies in different regions [1], [2].

The process of learning and the demonstration of mechanization's benefits emerge as other critical elements in understanding the demand for agricultural mechanization. By investigating the impacts of learning and technological spillover on the adoption of mechanization, the study explores the significant influence of farm-level experiences and the role of tractor owner-operators in dispersing demand and promoting mechanization in various agricultural settings. Moreover, the study explores the sequences in which demand for various mechanization modalities arises. It emphasizes how different functions being automated, the types of mechanization technology, and the characteristics of farming communities contribute to the successive emergence of mechanization demand. As the study evaluates the order in which mechanization technologies are adopted, it provides valuable insights into the factors governing their prioritization based on their relevance, efficiency, and applicability. By synthesizing evidence and empirical findings from diverse regions and agricultural systems, this study seeks to establish a comprehensive understanding of the factors influencing the demand for agricultural mechanization. The insights gained from this research will not only contribute to academic knowledge but also prove instrumental in formulating policies and strategies to promote sustainable and inclusive agricultural development worldwide. In the face of evolving challenges and opportunities in the agricultural sector, this study serves as a critical resource for stakeholders, policymakers, and researchers working towards enhancing agricultural productivity, efficiency, and overall socio-economic well-being [3], [4].

Complementary Technologies

The returns from mechanization and, consequently, the demand for it, may be impacted by the prices and accessibility of complementing non-labor inputs. As predicted by Boserup (1965), the use of land-saving technology throughout the intensification process, such as chemical fertilizers, necessitates more work, which raises the need for mechanization. Although yields were noticeably higher on South Asian farms that used tractors for plowing, Binswanger (1978) discovered that almost all of these occurrences could be attributable to greater usage of

fertilizer. In Northern Ghana, mechanization does indeed seem to be associated with fertilizer and herbicide use, with herbicide being used as a complement to tractors to kill weeds prior to tractor plowing. In addition, Nin-Pratt and McBride (2014) discover that using land-saving technology in Ghana is often inefficient unless it is used in conjunction with mechanization, which suggests that having access to mechanization is crucial for making labor-intensive technologies practical.

In West African rice irrigation systems, the connection between the need for mechanization and the accessibility of auxiliary technologies is further illustrated. Owner-operators are renting out power tillers and harvesters to cover the full irrigation system area in Ghana's Kpong Irrigation System, which was initially subsidized by the government although this may only be possible since there are many tiny plots adjacent to one another. Power tillers and combine harvesters, which are used on 48% of the system's area, were subsequently introduced by private investors. It appears that the profitability of irrigated rice farming has increased demand for mechanical tillage and harvesting, as well as for seeds, fertilizer chemicals, a market for land leasing, and private milling. Although the exact order in which technologies are adopted is unknown, it is clear that mechanization is essential for a successful case of agricultural transformation. It is crucial to emphasize that mechanization typically does not immediately increase yields because there is typically little to no difference in yields between tractors, animal traction, and hand hoe tillage. The exception to this rule is when mechanized plowing can more effectively absorb crop waste and thick soils prevent hand tilling. But by encouraging the use of complementing technologies and enabling time-sensitive tasks to be finished at the right times, as was previously discussed, mechanization may inadvertently increase yields [5], [6].

Utilization and Income generation Potential

Although the specifics of various service providing models will be covered in its own area, the extent and profitability of service provision is a significant factor in medium to large farmers' need for mechanized equipment. Tractor owners can profit by leasing out mechanization services where there is a high demand for mechanization among farmers, even if area growth is not feasible due to land limits or a shoddy tenure structure. This is valid for both tractors and animals, where owners have been able to exceed the amount of land plowed to break even in order to achieve a profit on their investment. In addition to providing services to nearby farmers, some owners may decide to relocate with their equipment to regions with distinct seasons for plow and harvest. This has allowed Chinese owners of small-sized combine harvesters to work eight months out of the year, a model that will be covered in more detail later in this study. By employing the engine to power a tractor-mounted threshing machine or water pump or by leveraging transportation services, the employment of tractors and power tillers can be expanded to tasks other than land preparation. However, the incentive for owning machines is diminished if the hiring market is unattractive for the primary use of tractors in plowing. This can happen due to a lack of farmer demand for hiring-in such services, fragmented farmland that raises the cost-of-service provision, or service charges being depressed by government-subsidized provision.

Learning and Demonstration of Mechanization's benefits

The diffusion of mechanized technology may be best understood by considering the impacts of learning and technological spillover. The effects of tractors and other large machines can be seen on the farms where they are used as well as sampled through hiring in services. In Ghana, according to a survey of tractor owners, 90% used services before buying their tractors. It may also help new owners get over the expenses of adaptation associated with adopting tractors if they are familiar with service delivery models in addition to the equipment themselves. The likelihood of these consequences emphasizes how crucial it is to establish networks of tractor owner-operators to disperse demand across potential owners. In spite of the programs' financial unviability, demonstration has been identified as a key driver for a number of government tractor projects, and it appears to have had the desired impact in Thailand and Malaysia. To what extent learning and spillover influence the need for mechanization, however, there is little empirical evidence in Africa.

Sequences of Mechanization Demand

After identifying the elements of mechanization demand, this part will go over the order in which demand for various mechanization modalities arises. According to, depending on the many functions being automated, the various types of mechanization technology, and the various groups of farmers, the demand for mechanization emerges successively. In contrast to control-intensive operations like weeding and winnowing, which are often mechanized after wage rates have increased significantly, power-intensive services, starting with plowing and including threshing, milling, and transport, are the first to be automated. According to stationary operations often undergo mechanization before mobile ones. When it is practical, the need for animal power also frequently arises before the need for mechanical power. An overview of these processes is shown in Figure 1 [7], [8].

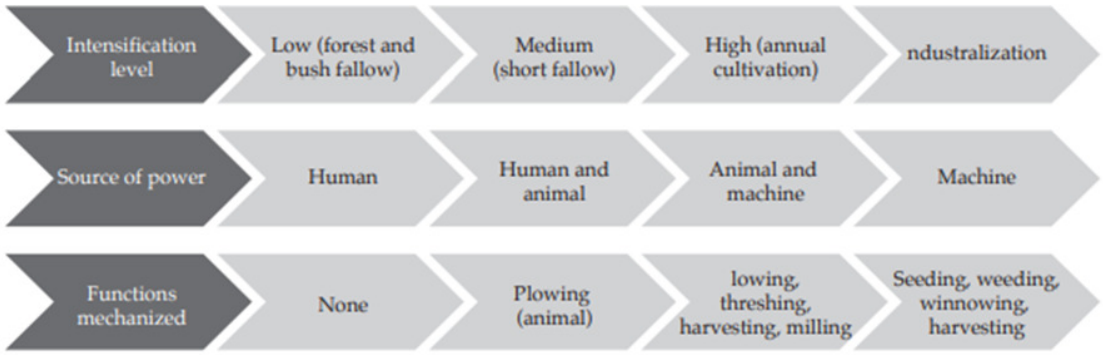


Figure 1: Overview of Sequential Adoption of Mechanization.

Demand for Mechanized Plowing

One of the first significant operations to be mechanized is often plowing. Only after switching to yearly agriculture is it possible to use both tractor and animal plowing to prepare the ground.

Demand for Animal Traction

The concept developed by Pingali et al. (1987) states that animal traction becomes lucrative when the grass is fallow. The need to remove tree stumps from fields vanishes at this point, when population density is at least 16–64 people per square kilometer, but there is still enough of space for grazing and fodder crops. However, as systems get more complex, grazing and fodder crop land starts to diminish, making it harder to keep draught animals.

Though their prevalence decreases as population density rises, the presence of tsetse flies, which cause trypanosomiasis in cattle, can be a prohibitive barrier to maintaining livestock (Pingali et al 1987). Tsetse flies impact livestock in most of West Africa, with the exception of the less fertile Sahelian regions, while they are less prevalent in some areas of East Africa, according to Figure 2 which depicts the distribution of cattle and tsetse flies across Africa. Due to droughts, illness, theft, and poverty causing communities to sell up their belongings, there has been a decrease in the usage of draft animals in addition to trypanosomiasis, even in places where it was common (Bishop-Sambrook 2005). The inconsistent adoption of animal traction may also be explained by climatic and market considerations. Animal traction is unproductive in Sahelian zones in Burkina Faso and Niger due to the short planting seasons and light, sandy soils (Jaeger and Matlon 1990; Williams 1996). When employed for cash commodities with a ready market, such groundnuts and cotton in West Africa, the need for animal traction is higher (Jaeger and Matlon 1990). Adopting animal traction in the Sudan savannah of Niger could necessitate a switch from root crops to these cash crops in order to be viable (Williams 1996).

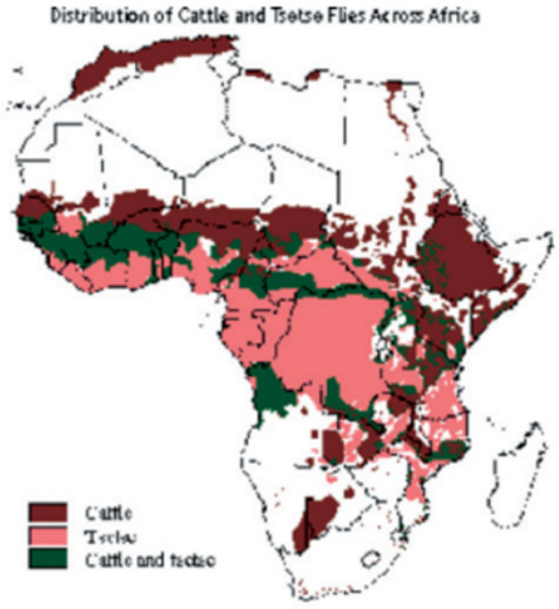


Figure 2: Map of Cattle and Tsetse Fly Distribution in Africa.

Animal traction costs include more than just the price of the animals and the tools. Feed costs, animal maintenance expenses, such as the direct and indirect costs of grazing and fallow land, as well as veterinary services, are among them. Households that need to change their labor allocation and acquire new skills may incur a large adjustment cost. The transition period has

been observed to take up to seven years before animal consumption reaches economic levels, but this may be less noticeable in communities where cattle raising is a tradition. Furthermore, while the advantages of plowing are only experienced for a few months each year, these expenses are ongoing. Although it is unknown if this still holds true in Africa now, keeping draft animals occasionally required larger economies of scale than tractors.

Animal ownership is frequently not driven only by the need to produce draft work, as they also provide milk, meat, organic fertilizer, insurance, social benefits, and value growth over time. These additional livestock uses must also be taken into consideration because they may have an impact on farmers' desire to employ their livestock for draft purposes. In addition to reducing costs, leasing livestock for plow work and transporting goods allowed 71% of surveyed animal owners in Ghana's two northernmost regions to plow more acres than was necessary to break even and turn a profit on their investment.

Therefore, even though animal traction has several advantages that go beyond what is often possible with mechanization, there are also many issues that could be restricting. This will probably result in some clusters where it is economic, sustainable, and hence extensively embraced, and other places where it is not practical and is only sometimes seen. In some regions, it might be possible or perhaps necessary to forego using animal traction and move straight from the manual hoe to engine-powered automation [9], [10].

DISCUSSION

Demand for Large and small Tractors

Tractor plowing may become economically viable once population density reaches the point where annual cultivation is required. However, in flood plains, valleys, and treeless mountains, as well as in regions unsuited to rearing draught animals, tractor use may develop immediately after the hand hoe. In areas that have adopted animal traction, tractor use often follows it. There may be better production conditions, particularly for irrigated rice, in these treeless areas where de-stumping costs do not limit the employment of the plow. Tractors, on the other hand, cannot be employed in locations with steep slopes or other challenging terrain; these areas may promote extensive hand-hoe cultivation and enhanced dairy and tree crop output.

2-wheel power tillers, which are separately and frequently wrongly categorized as "pedestrian controlled tractors" although performing the same activities as 4-wheel tractors, are not included in the FAO's definition of tractors because they only include 4-wheel machines. Power tillers, which normally have 20 horsepower or fewer, are in demand because they are more maneuverable and can be used to their full capacity in systems with limited landholdings, they are less expensive than 4-wheel tractors, they have the possibility for off-farm use, and they are suitable for wet paddy. Many mechanization advocates have pushed for the promotion of 2-wheel tractors in Africa, but they have only sometimes been accepted outside of areas where governments have actively encouraged them. This is especially true because of the first three of these reasons. 2-wheel tractors, on the other hand, are frequently thought to be difficult to use in most of Africa because they are not ideal for conventional tillage of dry, heavy soils. These elements contribute to their rapid spread in Asian nations including Bangladesh, Sri Lanka, and Vietnam as well as in irrigation projects in West Africa, Tanzania, and Ethiopia. However, in some regions of South Asia, especially where rice-non-rice crop rotations are prevalent, 4-wheel tractors are more common than 2-wheel tractors.

Only information on 4-wheel tractor use in 24 African nations is available when it comes to the quantity of tractors currently in use in various nations. The majority of these tractors are found in South Africa and North African nations, followed by sizable nations with significant commercial agriculture industries like Nigeria, Tanzania, and Kenya. It's crucial to recognize the need for various tractor sizes. Smaller 4-wheel tractors and 2-wheel power tillers are preferred by small- and medium-sized farmers in Africa because they are more affordable and require less space to operate. With the fast adoption of power tillers and India's preference for small 4-wheel tractors with 20–40 HP, this has happened over much of Asia. In Figure 3 shown the most recent available estimate of 4-wheel tractors in use.

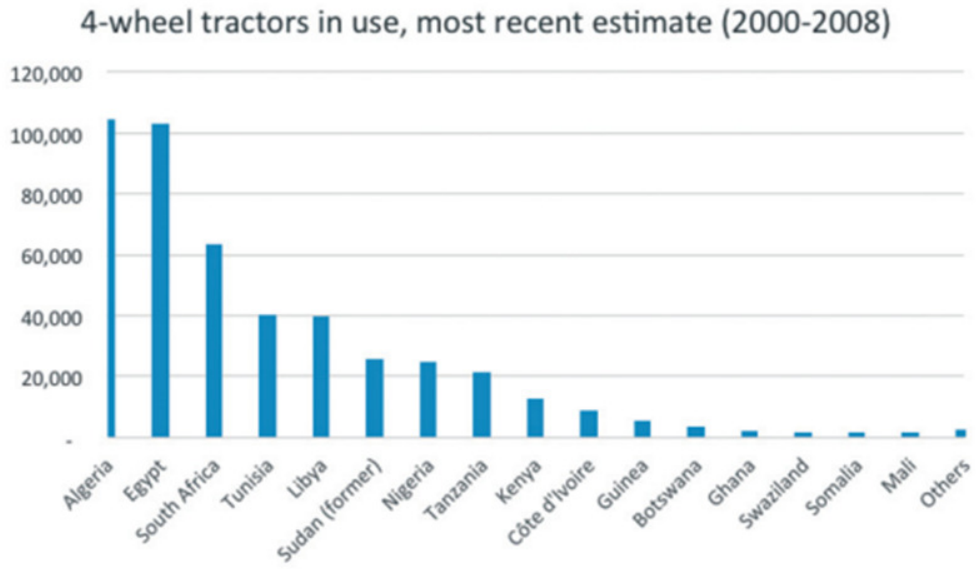


Figure 3: Most recent available estimate of 4-wheel tractors in use.

Table 1: Average 4-wheel tractor horsepower in selected countries.

	Burkina Faso	Ethiopia	Ghana	Kenya	Mozambique	Nigeria	Zambia
Estimated Average Tractor HP	40-60	102.3	60-80	101.4	84.9	65-80	65

Source: World Bank (2014b)

However, Table 1 shows that in all of the aforementioned nations, tractors in Africa are significantly bigger than those in Asia. Although farms in Africa are typically larger than those in Asia, this does not seem to entirely account for the difference in tractor size; according to Chancellor (1986), 20 ha can be plowed with just 16 HP of mechanical power. Although renting out services can help make machine ownership lucrative when it cannot be fully utilized on the owner's farm, this is not usually the main reason for tractor ownership. Therefore, it does not seem realistic that farmers are motivated to buy larger machines by the possibility of contracting out services. The size of tractors also increased as farms grew larger and farm households became wealthier in most other places during earlier stages of mechanization. The initial adoption of huge tractors in Ghana and Nigeria does not seem to follow this pattern, and

there also don't seem to be enough cost-per-horsepower savings gained by large tractors to justify their domination. Farmers may favor high horsepower tractors after witnessing the huge sized tractors often used on state and commercial farms before purchasing their own, even if there are no clear causes for this trend. The prestige of having large machinery may also be viewed as a desirable investment by farmers when they first start to invest in tractors due to this perception impact. Thus, the factors that influence tractor size demand are a subject that need more investigation.

Demand for Post Harvest Mechanism

The need for mechanized threshing, according to develops in two stages. When a need for mechanical harvesting arises, combine harvesters are adopted and take over threshing activities. Initially, crops are harvested manually and subsequently threshed using pedal- or engine-powered devices. Even when wages are low, the need for robotic threshing arises when harvested volumes rise as a result of increased yields and when multiple cropping produces a manpower shortage between harvest and the following planting season. Due to their greater reliance on hired labor, medium-scale farmers are more likely to be impacted by these situations. Combine harvesters, which carry out both harvesting and threshing tasks, may start to be used as these limits tighten and salaries rise. When opposed to utilizing a combine harvester, human threshing results in significant grain losses, on the range of between 20 and 35% depending on the crop and system. Additionally, one of the more taxing agricultural duties is hand threshing, which is often done by women.

Threshing equipment can be purchased in many African nations and is typically made locally for a reasonable price. When there is a need for automated threshing among other farmers, owners can easily contract out threshing services. There is a demand for mechanized threshing among farmers in high-potential rice areas, and locally developed technology can (to a certain extent) meet this demand, according to research conducted in the Senegal River Valley, where 86% of surveyed rice producers who were exposed to the ASI thresher adopted it. There are also tractor mounted threshing machines available, which may help extend the use of tractors past the plowing season and give tractor owners an additional incentive to mechanize threshing (Houssou et al. 2014).

Demand for Mechanized Harvesting

Grain and root crop harvesting is a control-intensive process that also demands a significant amount of power. As a result, once automated plowing and threshing are used, it is always mechanized and rarely viable in low-wage nations. This suggests that demand for mechanical harvesting in Africa should be extremely modest and limited to regions with exceptionally high pay. The harvesting can be automated using reaper machines or small and big combine harvesters that also thresh the grain. Although it is uncommon overall, there do seem to be some areas where demand for mechanized harvesting has emerged. These areas are primarily in rice irrigation schemes in West Africa and Kenya as well as cereal systems like those for wheat in Kenya and Ethiopia. When crop loss from manual harvesting and threshing is taken into account, hiring combine harvester services is frequently attractive and even less expensive than hiring labor for manual harvesting and threshing, which generates demand for hiring such services among smallholders in some areas. However, the demand for automated harvesting on

the continent will probably be constrained until a dramatic increase in rural incomes is noted and/or large farmers who can afford to invest in a machine start to appear more frequently.

Spatial Variations of Mechanization Demand

Given the intricate and varied demand factors we've just covered, we can anticipate significant regional variance in both the prospective demand and mechanization adoption. This is also true since regional differences in agro-ecological conditions have a significant impact on agricultural production. As a result, it is impossible for national statistics and data to provide a precise picture of demand. The estimations in Table 2 below, which the World Bank compiled from national ministries, show that Africa has modest but varied levels of mechanization using 4-wheel tractors as a proxy. These estimates, however, mask the variety of mechanization forms and regional variations. Additionally, Ethiopia, Ghana, Nigeria, and Tanzania in particular, some of the nations with very low tractor density estimates, look to be making some of the most noticeable advances toward mechanization. The same seems to be true for national statistics on cropland availability per agricultural worker (Figure 4); low land availability per worker on a national level may hide the existence of regions where there is still land available for commercial production and requires labor-saving technology to cultivate.

Table 2: Tractors per 100 sq km.

Country	Burkina Faso	Ethiopia	Ghana	Kenya	Mozambique	Nigeria
Tractors	8.9	4	11	26.9	12.7	5.7
	Rwanda	**South Africa**	**Tanzania**	**Tunisia**	**Zambia**	**Zimbabwe**
	1.3	43	7.4	143	20.7	35.6

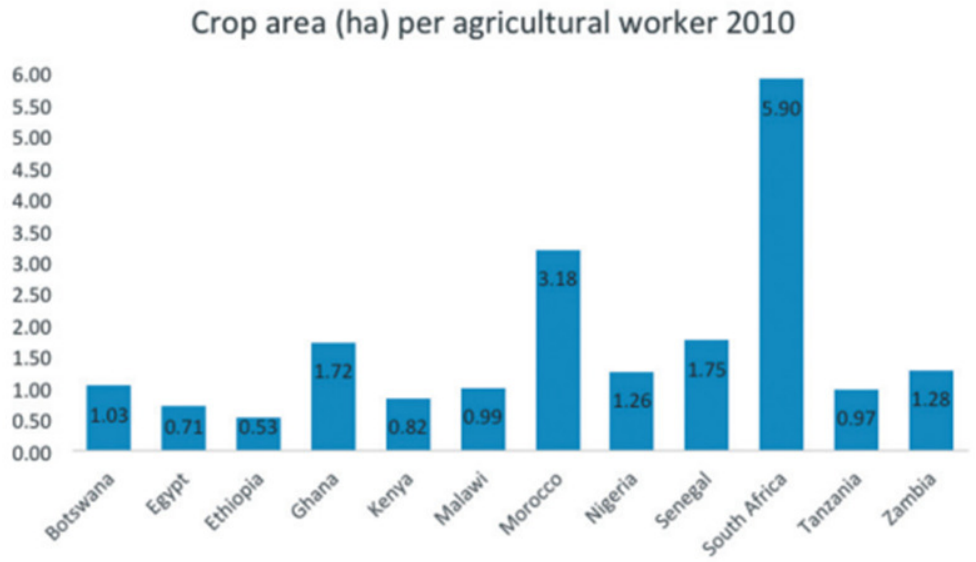


Figure 4: Crop area per agricultural worker.

For instance, Ethiopia would not be a good candidate for mechanization due to its high population density and poor amount of agricultural land per worker. Ethiopia would be

disregarded in a discussion of mechanization based on national data due to its extremely low tractor density of 4 per 100 square km, yet there is still a lively mechanization process taking place in several areas of the country. While the heavily populated central highlands, where tractors are rarely used and animal traction is common, have an impact on these figures, mechanized commercial agriculture is actively sought in the western highlands, where fertile land is still available. Additionally, while Zimbabwe appears to be quite tractorized compared to other African nations, with 35.6 tractors per 100 square kilometers, over 75% of tractor use is concentrated in the A2 commercial farming sector, suggesting that the majority of smallholder farmers have limited access to tractors. As a result, it's possible that national figures don't accurately reflect the dynamics of mechanization use.

According to the need for mechanization in Ghana might differ significantly between adjacent areas depending on market accessibility and population density. Additionally, there may be considerable variations in tractor service fees between districts, which results in a breakeven area of plowed land that is twice as large between two districts. In Ghana, animal traction is also confined in a small number of districts in the two northernmost regions and is seldom ever utilized elsewhere. Similar spatial differences in mechanization trends can be seen in Kenya, where mechanization is concentrated in the high-potential Rift Valley, and Zambia, where 60% of tractors are concentrated in two of the country's nine provinces (Central and Southern). In Nigeria, the Central and Northern zones where root crops are grown are where tractors and animal traction are most commonly used. A research conducted by Bishop-Sambrook (2005) of 14 communities in 7 African nations helps to highlight some of the variety among communities. She describes the development of manual labor, animal traction, and tractor-based systems, illustrating how they differ between and among nations in order to give a quick overview of the variations in mechanization requirements.

For instance, the 34% of farmers in Mvomero, Tanzania who use tractors along with 10% who use animal traction defies the national statistics showing a sparse use of mechanization and contrasts with the 60% of farmers in Msingisi, a maize-dominant system in the Morogoro region, who use animal traction along with 10% who use tractors. Other studies in Western Tanzanian districts have estimated that over 90% of traction is provided by animals. Additionally, there are variations at the local level between the percentage of farmers using their own animals or machines or the labor market. In conclusion, mechanization is typically adopted when farmers want to increase the size of their land or overcome labor shortages, when market demand is rising not just for cash crops but also for food crops, and when machine utilization through the hiring market can be enhanced. In most cases in Africa, these factors experience significant spatial variation, necessitating more detailed and localized data to accurately describe mechanization both across and within regions.

CONCLUSION

The demand for robotic harvesting and post-harvesting systems is driven by the desire to increase production, decrease labor requirements, and improve efficiency. Mechanized harvesting offers benefits such as enhanced efficiency, reduced crop loss, and increased speed. Farmers are increasingly using technology to streamline their harvest processes and satisfy rising agricultural produce demand. However, the demand for robotic harvesting varies geographically due to factors like crop types, field sizes, topography, and local labor dynamics. Manufacturers, decision-makers, and service providers must understand these geographical

variances to focus on market demands. Post-harvest procedures, such as sorting, cleaning, grading, and packaging, are crucial for maintaining freshness and marketability of agricultural produce. These processes can be made more efficient, waste eliminated, and product consistency improved. Factors such as crop types, market demands, infrastructure availability, and processing capacities also affect the demand for post-harvest systems. To offer suitable and effective post-harvest solutions, processing, storage, and distribution industries must evaluate the unique requirements and difficulties of each location or crop.

REFERENCES

[1] R. Wang et al., "Inter-provincial Differences in Rice Multi-cropping Changes in Main Double-cropping Rice Area in China: Evidence from Provinces and Households," Chinese Geogr. Sci., 2019, doi: 10.1007/s11769-018-0972-4.

[2] X. Hui, Y. Sun, F. Yin, and W. Dun, "Trend Prediction of Agricultural Machinery Power in China Coastal Areas Based on Grey Relational Analysis," J. Coast. Res., 2020, doi: 10.2112/SI103-063.1.

[3] G. Du, Y. Liu, F. Yu, M. Liu, and H. Zheng, "Evolution of concepts of cultivated land quality and recognition," Nongye Gongcheng Xuebao/Transactions Chinese Soc. Agric. Eng., 2016, doi: 10.11975/j.issn.1002-6819.2016.14.032.

[4] W. Li, C. Xue, S. Yao, and R. Zhu, "Demand and Its Influencing Factors of Households' Mechanization in Mountainous Orchard," Linye Kexue/Scientia Silvae Sin., 2017, doi: 10.11707/j.1001-7488.20170214.

[5] Z. Li, X. Ma, L. Liang, and L. Qi, "Analysis of influence factors on development of rice planting mechanization based on grey correlation analysis," Yingyong Jichu yu Gongcheng Kexue Xuebao/Journal Basic Sci. Eng., 2013, doi: 10.3969/j.issn.1005-0930.2013.06.017.

[6] J. P. B. Cunha, F. M. da Silva, R. E. B. A. Dias, C. F. Lisboa, and T. de A. Machado, "Viabilidade técnica e econômica de diferentes sistemas de colheita do café," Coffee Sci., 2016.

[7] D. Albiero, R. S. Xavier, A. P. Garcia, A. R. Marques, and R. L. Rodrigues, "The technological level of agricultural mechanization in the State of Ceará, Brazil," Eng. Agric., 2019, doi: 10.1590/1809-4430-Eng.Agric.v39n1p133-138/2019.

[8] M. Jiang, X. Hu, J. Chunga, Z. Lin, and R. Fei, "Does the popularization of agricultural mechanization improve energy-environment performance in China's agricultural sector?," J. Clean. Prod., 2020, doi: 10.1016/j.jclepro.2020.124210.

[9] Y. Minli, L. Minzan, and L. Xiwen, "50 Years of agricultural mechanization in China," AMA, Agric. Mech. Asia, Africa Lat. Am., 2020.

[10] P. Pingali, "Chapter 54 Agricultural Mechanization: Adoption Patterns and Economic Impact," Handbook of Agricultural Economics. 2007. doi: 10.1016/S1574-0072(06)03054-4.

CHAPTER 6

AN OVERVIEW OF THE MECHANISM SUPPLY CHAIN IN AFRICA

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

The African mechanism supply chain is crucial for ensuring the availability, affordability, and accessibility of equipment, spare parts, maintenance services, and technical support across the continent. However, it faces difficulties such as low local manufacturing capacity, weak distribution networks, lack of financing choices, and restricted availability of high-quality replacement parts. These issues hinder the general adoption and efficient use of agricultural gear. To address these issues, multiple parties, including producers, distributors, financial institutions, policymakers, and development organizations, must work together. Local production and assembly of machinery can lower prices and increase availability. Efficient distribution networks and service facilities can increase accessibility and provide essential technical support. Farmers need access to finance options, and partnerships between financial institutions, producers, and distributors can provide affordable financing mechanisms. Technical skill development among farmers, service providers, and technicians is essential through capacity-building programs and training efforts. Fostering a supportive environment for the mechanism supply chain requires strong policy backing, encouraging regional production, lowering import tariffs, simplifying customs procedures, enforcing safety and environmental requirements, and guaranteeing the availability of high-quality replacement components. By bolstering the supply chain infrastructure, Africa can harness its agricultural potential, increase productivity, improve rural livelihoods, and contribute to food security.

KEYWORDS:

Distribution, Efficiency, Logistics, Manufacturing, Operations, Transportation.

INTRODUCTION

The supply chain in Africa is a fundamental component of the continent's economic landscape, serving as the backbone of industrial development and international trade relations. It plays a vital role in facilitating the movement of goods, raw materials, and services within and beyond Africa's borders. At its core, the supply chain in Africa involves a complex web of activities, from sourcing and procurement to production, distribution, and final delivery to consumers. This intricate network engages a diverse range of stakeholders, including suppliers, manufacturers, logistics providers, retailers, and consumers, all collaborating to ensure the smooth flow of products and services throughout the region. However, the African supply chain faces a host of challenges that impede its seamless functioning and hinder economic growth. One of the most pressing issues is the inadequacy of infrastructure across the continent. Underdeveloped road networks, limited rail connectivity, and inefficient port facilities contribute to higher transportation costs and longer lead times, making it difficult to move goods efficiently. Addressing these infrastructure gaps is crucial to unlocking the true potential of the supply chain in Africa [1], [2].

Moreover, the continent's technology adoption remains a critical factor in optimizing supply chain operations. Embracing modern technologies, such as advanced logistics management systems, real-time tracking and monitoring tools, and digital platforms, can streamline processes, reduce inefficiencies, and provide valuable data for informed decision-making. However, there are disparities in technology access and adoption across different regions, which need to be addressed to achieve a more interconnected and efficient supply chain ecosystem. Another significant challenge lies in the realm of inventory management and warehousing. Effective inventory management is essential for maintaining appropriate stock levels, preventing stockouts, and optimizing working capital. However, inadequate warehousing facilities and practices often lead to higher inventory carrying costs and operational inefficiencies. Improved warehousing standards and practices can mitigate these challenges and contribute to a more robust supply chain network in Africa.

The complexities of cross-border trade also present challenges for the supply chain in Africa. Political instability, corruption, and bureaucratic hurdles at border crossings can lead to delays and additional costs for companies engaged in regional and international trade. Enhancing customs procedures and regulatory frameworks can facilitate smoother cross-border movements, fostering greater regional integration and boosting trade opportunities. Despite these challenges, the supply chain in Africa also holds immense potential and opportunities for growth. As Africa's industrial sector continues to develop and its consumer base expands, there is a growing demand for efficient and reliable supply chain mechanisms. Investments in infrastructure, technology, and capacity building can unlock the continent's supply chain's untapped potential, driving economic development and prosperity. The mechanism of the supply chain in Africa plays a vital role in the continent's economic advancement and global trade relations. While facing various challenges, the continent has the opportunity to leverage technology, improve infrastructure, and enhance cross-border trade to create a more efficient, interconnected, and sustainable supply chain ecosystem. By doing so, Africa can harness its vast potential and transform its supply chain into a catalyst for economic growth and prosperity in the region. This section examines the variables that affect mechanization supply before concentrating on the demand side of mechanization by giving a thorough rundown of the supply chains for engine-powered mechanization in Africa [3], [4].

The Supply Chain as a Framework

The production and distribution of a thing or service among various parties is referred to as a supply chain. To define the scope and typology of the mechanization processes occurring in Africa and to pinpoint the bottlenecks where supply is not keeping up with demand, a supply chain analysis is a valuable framework. The manufacturing and importing of machines, the delivery of mechanized services, and the provision of spare parts and repair services for machinery maintenance are all included in the supply chains for mechanization. Because it is integrated with larger livestock value chains, the supply chain for animal traction is not included in this section on supply networks for mechanization.

Development of Supply Chain

The experiences with technology that are passed down from previous generations, exogenously introduced, or adopted through induced innovation lead to the development of significant supply chain components. The use of agricultural mechanization technologies in Africa before to colonialism was not very common. While several societies have a history of keeping animals, the ard plow or maresha in Ethiopia is possibly the only animal traction device known to have existed in Africa prior to the colonial era. In other places, colonial governments and settlers were primarily responsible for introducing animal traction and engine-powered

mechanization. While colonial and post-independence governments continued to aggressively encourage mechanization in some instances, technology spread more spontaneously in other situations. According to induced innovation hypothesis, farmers would create or adopt new technologies in an effort to replace limited factors with abundant ones if factor endowments shift. This seems to have been the case for the evolution of animal traction in many areas of East Africa, where agricultural intensification was brought about by natural population pressure and a move towards marketable crops like cotton.

The factors that encourage the use of mechanization have an impact on the supply chain designs as well. The supply chain that forms when private demand organically occurs is normally formed by the nature of the demand, and the technologies that owners and users like are typically either produced or imported. However, the types of technologies employed when mechanization is introduced, often through governments or foreign NGOs, are not always suitable for local conditions. During colonial animal traction development efforts, for instance, huge, heavy plows made for European oxen and soils performed poorly in most African circumstances. In Ghana today, a comparable situation is seen between the parallel private and public market channels for tractors. Private sellers import the majority of used tractors from the brands that farmers choose and for which parts and repairs are accessible. Governments, on the other hand, routinely import brand-new tractors that they have preferential access to through loans with reduced interest rates, despite the fact that these brands have fewer well-known mechanics and scarce spare parts. However, private supply chains may require technical, policy, or coordinating support in order to function effectively because they are not always able, at least in the near term, to provide the complete range of equipment and services that farmers demand [5], [6].

Key Players and their Functions in Mechanization Supply Chains

Manufacturers, virtually all of them are major multinational corporations with headquarters in the US, Europe, or Asia, are where the supply chain for new machinery utilized in Africa begins. Tractors are heavily dependent on foreign multinational corporations as their suppliers, in contrast to smaller equipment like threshers and other straightforward implements, which are frequently made locally in a number of African nations. In African nations, there are three main importation routes, including direct government importation of new equipment and private importation of both new and used machines. A government may occasionally import equipment via a private business.

Then, there are three primary service delivery models: (1) direct government service provision, which provides farmers with plowing services from public hiring stations, frequently at a discounted rate; specialized private service provision models, which are purportedly private businesses that hire out mechanization services without having their own cultivated farms they were established in Ghana and Nigeria through a government credit scheme); and private farmer-to-farmer service provision. Large, medium, and small farmers are the final consumers of mechanization technology, and each of these groups uses the technology in a unique way depending on the situation. Retailers of new and used tractors, dealers in spare parts, fabricators, and mechanics all help the supply chain. Figure 1 depicts the supply chain's organizational structure, which is further explained in the sections that follow.

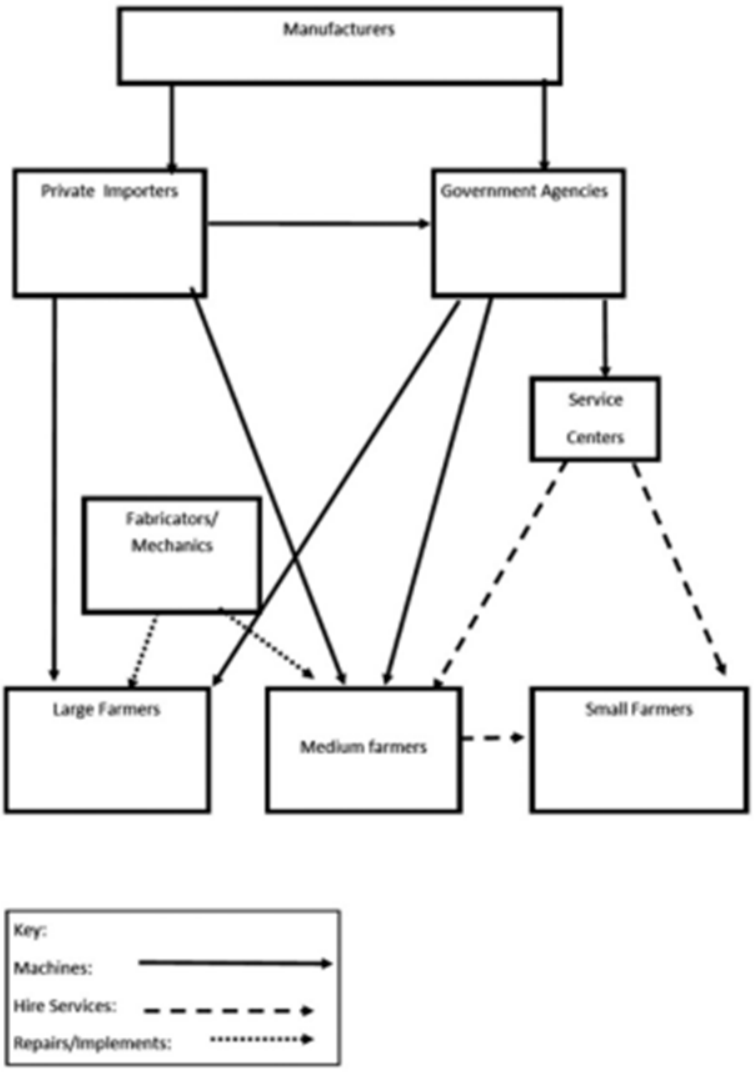


Figure 1: A Supply-Chain Diagram for Mechanization in Africa.

DISCUSSION

Importation

Due to the almost complete lack of local manufacturing capacity, the tractors, power tillers, and combine harvesters used in Africa are almost completely produced outside of the continent. Africa's mechanization developments reflect the global manufacturing sector. Previously, machines were typically imported from Europe and Japan, but as the manufacturing of agricultural equipment in these nations has grown, more machines are now coming from Brazil, India, China, Korea, Thailand, Turkey, and the Czech Republic. India has surpassed Japan and European nations to become the world's largest tractor maker. Since 2000, China has exported more power tillers than any other country, followed by Thailand and Japan (FAOSTAT). In China and India, the production of tractors, combine harvesters, and other mechanized equipment is frequently supported by sizable public R&D expenditures or consumer subsidies (India Ministry of Agriculture 2008).

Data on 4-wheel tractor imports by African nations is depicted in Figure 2. Unfortunately, data on tractor imports are only available from FAOSTAT for the year 2007, therefore this information may not reflect more recent trends. Additionally, as 2-wheel tractors are not included in the FAO's definition of agricultural tractors, these numbers are only available for imports of 4-wheel tractors. However, the data reveals that nations in Africa south of the Sahara with significant commercial agriculture sectors North Africa, South Africa, and those—are where most tractors are imported. According to FAO (2013), Africa now accounts for 11% of Chinese exports of large tractors, whereas according to Jain in Ashburner et al. (2009), Africa and ASEAN together only account for 5% of Indian exports. The tremendous expansion of Indian tractor exports to Africa, which is being fueled by concessional loans to African governments, may be missed by such numbers, though. Angola, Benin, Burkina Faso, Burundi, Cameroon, Chad, DRC, Guinea Bissau, Mali, and Swaziland are just a few of the nations that have recently received tractor loans with favorable terms from India (Diao et al. 2014). As a result, Indian brands are becoming the market leaders in a number of these nations [7], [8].

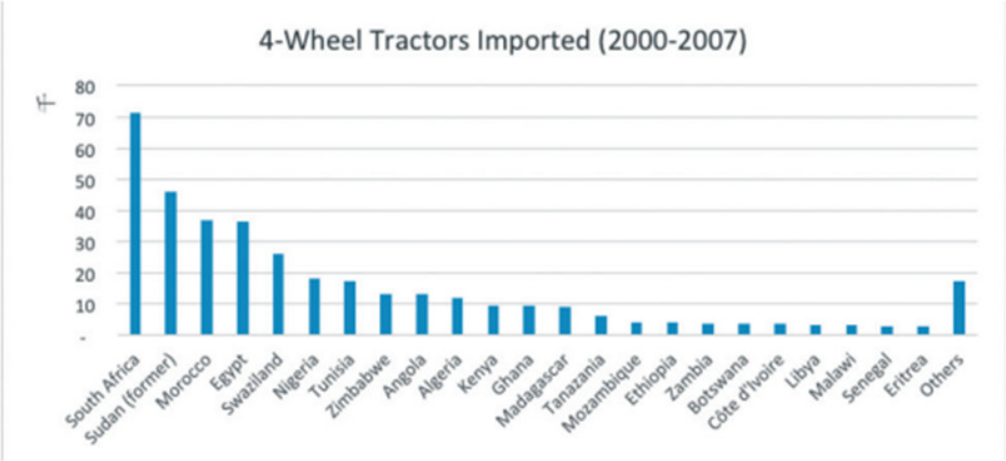


Figure 2: Agricultural tractor imports by African country, 2000-2007.

There has historically been a desire for inexpensive but "good enough" machines, at least in the early phases of mechanization, even though there is universal agreement that machines made in Japan and Europe are of greater quality than those made in emerging nations. The adoption of inexpensive Chinese power tillers has been especially quick in Bangladesh, where the lifting of import restrictions has led to their widespread use on 80% of the country's arable land. Owners of machines purchased through private market channels likewise exhibit the preference for "cheap but good enough" across Africa. Large 4-wheel tractors appear to be the main exception to this rule, while 2-wheel and small 4-wheel tractors are still far less frequently imported into Africa. The tendency for "cheap but good enough" appears to extend to the choice for used 4-wheel tractors as well, even if imports of Chinese power tillers are concentrated in a small number of nations, including Ethiopia and Tanzania. The introduction of 2-wheel tractors appears to depend on direct government encouragement.

Tanzania's government has made a concerted effort to promote the use of 2-wheel tractors, where there are currently about 6,000 power tillers in use. This effort includes distributing equipment through the District Agricultural Development Programs (DADPs), offering accessible credit through the Agricultural Inputs Trust Fund (AGITF), and establishing an agricultural window at the Tanzania Investment Bank. Along with it, import taxes have been eliminated, and the agriculture industry as a whole has been liberalized in the hopes that the private sector will take over after the government has encouraged demand. About three-

quarters of the 4,100 2-wheel tractors being used in Ethiopia, where initiatives are also being run by the Ministry of Agriculture and the Rural Job Creation Agency, were imported by a parastatal. Only a small number of 2WTs are probably in use in Kenya and Zimbabwe, where governments have not actively promoted them.

Donors and non-governmental organizations (NGOs) are frequently involved in the acquisition and distribution of tractors and other mechanization tools. Direct distribution to beneficiaries or assistance with government mechanization programs are two possible ways to do this. Other donors and organizations also offer technical assistance for mechanization, including education and capacity building for government stakeholders in the industry, instruction in the use and maintenance of machinery, displays of new and more useful technologies, and assistance throughout the supply chain [9], [10].

Through its development assistance organization, JICA (Japan International Cooperation Agency), the Japanese government has long encouraged mechanization throughout the world. The only requirement is that the manufacturer's headquarters must be located in an OECD country, though the tractors themselves can be and are manufactured or assembled elsewhere. This is in contrast to other bilateral donors who are more restrictive when it comes to the types of equipment that can be purchased with 2KR (Food Security Project for Underprivileged Farmers) grants. JICA's 2KR grants, which demand a 70% down payment and a payback period of three years but do not need founding a registered business as it does for AMSECs, had some effect on the design of Ghana's AMSEC program. The payback rates for 2KR tractors appear to be significantly higher than those for AMSEC loans, according to conversations with ministry representatives from Ghana. Other recent initiatives that focused on mechanization in Africa include the ADVANCE Project in Ghana, which provided equipment to 255 mechanization service providers in exchange for modest down payments from farmers as part of a value chain-wide strategy.

Mechanization will probably continue to rely on imported equipment because local production of mechanization equipment in Africa is still not very feasible. Private dealers create import and distribution channels where there is a need for mechanization, and the types of machinery the market can provide in turn affect demand. Governments may, however, intervene and make an effort to meet demand in cases where commercial channels are unable to do so or where automation is being pursued for political reasons. In a number of nations, government imports account for a sizeable portion of all imports and have a considerable impact on the supply chain, especially when those imports are financed by concessional loans that specify the place of origin or particular brand/type of machinery that must be imported. As a result, private supply channels are less able to respond to demand, and imports are increasingly influenced by governmental directives. As a result, brands that are dictated by the terms of concessional loans rather than farmer demand begin to dominate the market for sales, spare parts, and repairs, and it becomes more challenging to establish such brands through private channels (Diao et al. 2014). The use of high horsepower tractors may also have been pushed by governments providing them to farmers at reduced costs or by using them on state farms or hiring facilities. This might have led to the creation of a supply chain centered on these larger tractors and hindered the demand for smaller, perhaps more appropriate tractors.

Even while the government is highly active in importing tractors in Tanzania and Nigeria, where private importers are present, their percentage of overall imports ranges from 10% to 100% in Ethiopia, Ghana, Kenya, and Zambia (World Bank 2014b). However, these numbers show that governments use private enterprises to channel their imports; in reality, governments in Ethiopia, Ghana, and Kenya are heavily involved in tractor distribution and purchasing

(World Bank 2012a, 2012b, 2013a). In Zambia, private companies import 15% or more of the tractors through project-backed financing (World Bank 2012b). As a result, imports of tractors are even less driven by the private sector than would be implied by national figures. In addition, the government imports the large majority of new tractors into the bulk of African nations, with private importers concentrating primarily on used equipment. Table 1 shown the percent of private 4-wheel tractor imports in selected African countries.

Table 1: Percent of private 4-wheel tractor imports in selected African countries.

	Burkina Faso	Ethiopia	Ghana	Kenya	Mozam-bique	Nigeria	Rwanda	Tanzania	Zambia
% Private Imports	59	100*	100*	100*	60	19	42	10	100

* indicates significant government imports through private channels

According to, private importers often include both large dealers that set up franchises for well-known brands and importing businesses that deal in old tractors as part of a wide business portfolio. Private importers frequently also offer post-purchase services and repairs and keep replacement parts in stock for the brands they sell. In the majority of nations, there are normally eight to twelve sizable companies serving as agents for the particular brands they import and vying with one another (World Bank 2014b). Large-scale commercial farms and plantations are among their clients, but government agencies and donor-funded initiatives account for a sizable portion of their revenue. Individual farmers frequently cannot afford the expense of new imported machinery, especially given the absence of favorable financing terms.

The private import of new machines is restricted by limited access to acceptable loan terms for both private importers and potential buyers, which keeps private importers and customers confined to the secondhand machine market. As John Deere and its local distributor, AFGRI, are doing in Zambia with assistance from USAID and the Zambia National Farmers Union, some manufacturers are starting to collaborate with their local distributors to offer financing options to attract clients (World Bank 2012d). Dunavant, a cotton firm, runs a similar program in Zambia where it lends money to lead outgrowers so they may buy equipment and help other farmers. World Bank. Future studies should look into whether similar partnerships exist in Africa that are solely driven by the private sector, without assistance from donors or the government. While this is going on, used tractor importers often target medium-sized and big individual farmers, bringing in their favorite brands typically from Europe, which they value because they are well-known and have access to spare parts and repairs. Even though the market for imported tractors is largely seasonal, the majority of these companies still retain reliable import routes. Used tractors have dominated imports in recent years, even in nations like Ghana where governments purchased huge quantities of new tractors at heavily discounted prices.

They may even be less expensive than government-subsidized new tractors and may also cost less to maintain, especially when the market for spare parts is more developed for the second-hand brands, which is why farmers frequently find used machines to be more cost-effective. Even taking into account the age of the tractors, these may still be valid. It appears that many machines already in use have outlived their predicted usable lives of 5 to 12 years. In Tanzania, for instance, 85% of tractors in use are 11 years of age or older (World Bank 2012c). However, both new and secondhand tractors in Nigeria's survey are about the same age. Furthermore, it is known that farmers in Ghana and Nigeria who acquire their equipment through private channels do so at higher usage rates than farmers who get it through government channels.

Older tractors may be more prevalent due to the import-dependent structure and expansion of secondhand tractor market channels in some nations. In general, governments discourage the importing of used tractors. The rise in used tractor imports in several African nations is a singular testament to the capacity of the private sector supply chains to develop in response to farmers' wants and shifting supply of different brands of used tractors on international markets with just modest government backing. However, as will be discussed later, effective government assistance can help generate incentives that boost private import routes.

Manufacturing of Agricultural Machinery

Although a wide variety of imported machinery is utilized in Africa, very little of it is specially made for the region's conditions since manufacturers don't believe there is enough of a market there (Mrema et al. 2008). Joint venture plans have been used in a few attempts to pursue tractor production in Africa, such as the most recent one between AGCO and Algeria Tractors Company to make Massey Ferguson tractors (AGCO 2012). Past joint ventures have made some attempts to modify tractor designs to suit regional conditions. Due to their lack of competitiveness, the manufactured machines such as the Kabanyolo tractor in Uganda and the Tinkabi tractor in Swaziland were finally abandoned. Similar large investments were made in locally made animal equipment, but farmers never used them. These encounters have shown how challenging it is to create and produce machinery that can successfully compete with imports in terms of both quality and price.

There have been numerous attempts to create tractor assembly plants throughout Africa's history of mechanization, most of which have been unsuccessful. Government assembly plants have long since been closed in Tanzania, Nigeria, and other countries due to a lack of administrative effectiveness and technical capability. But the Nazareth Tractor Assembly Plant, built under the Derg dictatorship, is still in use in Ethiopia and can assemble about 300 tractors annually, which accounted for 46% of tractors that entered the Ethiopian market between 2005 and 2010 (World Bank 2012a). Although it is uncertain if they will be able to compete with new and used imports, other assembly facilities have been constructed by foreign manufacturers, frequently in partnership ventures with local governments or businesses. In order to successfully begin domestic production, joint ventures with foreign manufacturers are often required in the first years, according to experience in India, South Korea, and China. Nigeria has attempted similar joint ventures in the past (such as with Fiat), but these businesses failed because governments required foreign companies to employ locally produced, typically subpar parts. In Mali, Nigeria, Chad, and Cameroon, several Indian and Chinese businesses are launching joint and private operations. There may still be insufficient demand for tractors in many of these nations, casting doubt on the viability and motivation of these projects.

Tractor and other large machinery production generally does not appear to be a significant industry in Africa, despite the fact that African mechanization markets adapt to changes in the global industrial sector. Even if Africa's ability to assemble mechanized equipment seems sparse and dispersed, there are some regions where it would be worthwhile to pursue further. Before any significant investment can be made in these situations, it is necessary to determine the market demand for the technology being sought and the ability of local business to compete with imports. Fully and partially knocked down (SKD/CKD) parts are nevertheless frequently subject to the full tariffs even if the majority of nations have reduced import levies and VAT for imported tractors (World Bank 2014b). Governments might support this by abolishing or decreasing taxes on CKD parts and offering training programs to build the technical capacity needed by assembly factories if locally made tractors have a chance to compete with imports. Attempts should be made to court private investment while seeking local manufacture or

assembly; if such investments are not enticing to the private sector, they are unlikely to be practical.

CONCLUSION

The supply chain for agricultural machinery and equipment in Africa is crucial for its accessibility, affordability, and availability. However, obstacles such as high equipment costs, limited availability, poor distribution systems, and limited financing options hinder its efficiency. Stakeholder cooperation is essential to address these issues. To strengthen the mechanism supply chain, manufacturers, distributors, financial institutions, policymakers, and development organizations must collaborate. Local manufacturing and assembly of machinery are encouraged, and efficient distribution networks and service facilities can increase accessibility and technical support. Access to affordable finance options is essential for smallholder farmers and agribusinesses. Partnerships between financial institutions, producers, and distributors can facilitate creative financing methods for farmers to buy equipment. Capacity-building programs and training initiatives are necessary to develop technical skills among farmers, service providers, and technicians. Supportive policies, such as regional production, lower import tariffs, and simplified customs procedures, can boost the agricultural machinery sector. Regulations enforce safety and environmental requirements, guaranteeing the availability of high-quality replacement components. A robust and effective supply chain system promotes economic expansion, sustainable development, and food security, unlocking Africa's agricultural potential and improving rural livelihoods.

REFERENCES

[1] N. A. Mancheri et al., “Resilience in the tantalum supply chain,” Resour. Conserv. Recycl., 2018, doi: 10.1016/j.resconrec.2017.10.018.

[2] A. Acquaye, T. Ibn-Mohammed, A. Genovese, G. A. Afrifa, F. A. Yamoah, and E. Oppon, “A quantitative model for environmentally sustainable supply chain performance measurement,” Eur. J. Oper. Res., 2018, doi: 10.1016/j.ejor.2017.10.057.

[3] N. Shrestha et al., “The impact of COVID-19 on globalization,” One Heal., 2020, doi: 10.1016/j.onehlt.2020.100180.

[4] G. C. Mrema, J. Kienzle, and J. Mpagalile, “Current status and future prospects of agricultural mechanization in Sub-Saharan Africa [SSA],” AMA, Agricultural Mechanization in Asia, Africa and Latin America. 2018.

[5] T. Thorlakson, J. Hainmueller, and E. F. Lambin, “Improving environmental practices in agricultural supply chains: The role of company-led standards,” Glob. Environ. Chang., 2018, doi: 10.1016/j.gloenvcha.2017.10.006.

[6] M. Kanyane and M. Sisi, “Supply chain - A service delivery enhancement or an impediment,” Int. J. Manag. Pract., 2019, doi: 10.1504/IJMP.2019.096680.

[7] P. M. Pronyk et al., “The UN Commission on Life Saving Commodities 3 years on: Global progress update and results of a multicountry assessment,” Lancet Glob. Heal., 2016, doi: 10.1016/S2214-109X(16)00046-2.

[8] B. Tadesse, F. Bakala, and L. W. Mariam, “Assessment of postharvest loss along potato value chain: The case of Sheka Zone, southwest Ethiopia,” Agric. Food Secur., 2018, doi: 10.1186/s40066-018-0158-4.

[9] J. Barendse, D. Roux, B. Currie, N. Wilson, and C. Fabricius, “A broader view of stewardship to achieve conservation and sustainability goals in South Africa,” South African Journal of Science. 2016. doi: 10.17159/sajs.2016/20150359.

[10] J. Amankwah-Amoah, Y. A. Debrah, and D. Nuertey, “Institutional Legitimacy, Cross-Border Trade and Institutional Voids: Insights from the Cocoa Industry in Ghana,” J. Rural Stud., 2018, doi: 10.1016/j.jrurstud.2018.01.002.

CHAPTER 7

AN EXPLORATION OF THE FARMER-TO-FARMER SERVICE PROVISION

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

These abstract highlights the importance of understanding the relationship between ownership structures and the provision of specialized services to farmers in agriculture. Farmer ownership traits and specialized service provision are crucial in enhancing agricultural productivity, livelihoods, and sustainable farming practices. Ownership structures, such as individual and collective ownership, impact the provision of specialized services, such as technical knowledge, education, tools, and market data. The demand for these services is influenced by factors like farm size, education level, experience, and resource access. Smallholder farmers may rely more on external service providers, while large-scale farmers may have the financial resources to invest in their own specialized technology and equipment. Offering specialized services can be done through contracting, collaboration, or custom hire services, with service providers often possessing specific training, skills, and tools to deliver efficient and economical solutions. Access to these services is influenced by factors like service providers' capacity, market demand, and geographic location. Policymakers, extension agents, and service providers must recognize the connection between ownership traits and specialized service provision to improve agricultural productivity, livelihoods, and sustainable farming practices. Inclusive service supply should be promoted through improved infrastructure, rural connectivity, and targeted programs supporting smallholder farmers.

KEYWORDS:

Mechanization Strategy, Smallholder Farmers, Tractor Ownership, Farming Services, Farm Machinery.

INTRODUCTION

Individual farmers who frequently contract their labor out to other farmers and specialized hiring companies that do not engage in farming make up the majority of the owners of tractors and other agricultural equipment. These employment businesses, like the AMSEC program in Ghana and the AEHE program in Nigeria, are frequently supported by the government. Despite the failure and collapse of the majority of government hiring programs across the continent, several nations continue to offer direct government service.

Farmer-Ownership Characteristics

Both commercial estates and individual farmers own mechanization equipment. These estates may have numerous tractors and combines, but they hardly ever rent out equipment to surrounding farms, making them less important for smallholders' adoption of mechanization. Such massive business operations are frequently controlled by foreign investors; they are widespread in Kenya, Tanzania, Zambia, and Zimbabwe and are only starting to appear in

nations like Ethiopia, Ghana, and Nigeria. As may be predicted, mechanization equipment owners tend to be relatively large-scale farmers and have higher incomes than the average farmer. The results of the IFPRI/SARI survey in Ghana show that tractor owners have larger farms and higher uncultivated landholdings, implying that they have more room to grow their farms. Despite the fact that many tractor owners are larger farmers, they are sometimes unable to fully utilize their tractors due to the size of the field they are now cultivating. As a result, they are often compelled to seek services from non-owner farmers. Smaller farmers may own threshing machines, but only a small number of very large farms normally own combine harvesters. It appears that hiring services is a requirement for these farmers before they make an investment in combine harvesters or threshing machines. On the other hand, because most owners typically prefer to serve local customers, and because the mobility of machines, particularly of large tractors, is typically low in Africa, the ability of tractor owners to provide plowing services is dependent on the presence of nearby demand from local farmers. These owners buy tractors through both commercial and public means [1], [2].

In eight northern Ghanaian regions, an IFPRI/SARI survey revealed that the bulk of tractors held by individual farmers were acquired as used tractors from private importers. Only 13% of the tractors in the survey were brand-new tractors bought with government assistance, and 80% of them were used tractors. Even many new tractors' subsidized prices are more than the majority of used tractors in Ghana. Furthermore, only a small percentage of these tractor owners in the IFPRI/SARI survey favor the government-subsidized brands imported, as these brands are typically restricted to those produced in nations whose governments provided the Ghanaian government with concessional loans. The private sector imports used Massey Ferguson tractors from European nations; the majority of tractor owners prefer them. However, in several other African nations, government channels are where more farmers buy their tractors [3].

Despite the federal subsidy being removed in 2012, the combined state and federal subsidies resulted in total subsidies on tractors in some Nigerian states exceeding 60%. In Nigeria, private tractor owners utilized their equipment on more than 400 acres annually as opposed to only 250 acres for government-purchased tractors. This implies that farmers who want to and can use tractors more effectively might be able to buy their own tractors from the private supply chain, which may be a crucial factor for government distribution schemes to take into account. Tractors are often purchased by individual farmer-owners through private means without the use of credit or loans. According to the IFPRI/SARI survey in Ghana, 84% of medium-scale farmers bought their tractors with only their own money, and only 3.4% took out loans to do so. In a survey of tractor owners in the Nigerian states of Kaduna and Nasarawa, 82% of the funding for privately purchased tractors came from personal savings, 4% from bank loans, and 3% from government loans. This appears to be the case since there are very few credit markets for farmers to invest in machinery, with both tractor owners and non-owners seeing access to finance as the biggest obstacle to buying tractors.

A tractor is an expensive investment for the buyer, and since farmland cannot be used as security under traditional land tenure systems, the domestic financial sector is unlikely to lend money to farmers readily. Therefore, the obstacle potential tractor buyers who are farmers confront appears to go beyond a typical problem with the credit market. Without additional land market reform, this limitation is unlikely to be properly overcome. The majority of

extremely big private farmers that own combine harvesters either bought them or inherited them from defunct state farms; the latter is particularly prevalent in Tanzania and Ethiopia. Other farmers may still find it difficult to afford such a big machine, therefore they will instead rely on services that are available where they may be hired. Although they are uncommon elsewhere, reaper machines, which can typically harvest less than 1 ha of rice per day and are ideal for medium-scale fields, are widely utilized in northern Senegal and the Office du Niger in Mali. Threshing is a task that is mechanized earlier than harvesting, and machines are often far cheaper than tractors or combine harvesters, and can be reasonably simply made by local fabricators. As a result, ownership of threshing machines is more common. Though threshing is less time-bound than plowing depending on the crops and cropping methods, owning a thresher has less of a benefit in terms of timeliness than hiring one from the market. In some cereal systems, particularly those involving wheat, maize, and irrigated rice where the usage of combine harvesters has not yet taken off, threshing machines are frequently owned [4], [5].

Success Story: Farmer to Farmer Service Provision

In areas of Asia where demand has grown, a small percentage of farmers who own machines have been able to successfully supply a big percentage of farmers who use machines. For instance, the 2% of farmers in Bangladesh who possess power tillers are able to serve the 72% of all farmers who have mechanized primary tillage operations, according to a nationally representative survey. Similar findings have also been made for Nepal, Sri Lanka, and some regions of Thailand. The hiring market for 4-wheel tractors appears to be even more robust in Tunisia, where 90% of farmers in rainfed areas use tractors and 90% of tractor users hire them through the rental market. The majority of these countries utilize modest 2-wheel tractors.

Farmer to Farmer Service Provision

The supply of services from farmer to farmer has drawn increased attention in recent years as a key strategy for encouraging mechanization among small farmers in Africa . We view it as a crucial supply model for mechanization because it frequently manages to get around the administrative and technical shortcomings of other service provision models while allowing tractor and other machinery owners to make the most of their equipment. This increases the incentives for some farmers to invest in machinery. There must be enough large and medium farmers who can afford to invest in tractors and hence supply services, as well as adequate demand for mechanization among small and medium farms, for the hiringmarket to function properly. The scope of the hiring markets at the national level or across Africa cannot be quantified due to data limitations, although private farmer-to-farmer service supply has been seen in numerous African nations by IFPRI employees. This supply model appears to be active in a number of sites in Ghana and Nigeria, where more in-depth study has been done. A comparable model exists in Tunisia as well, and studies carried out for Asian nations by other academics have documented the patterns of service provision from farmer to farmer. Plowing, harvesting, hauling, and post-harvest threshing are a few examples of these services [6], [7].

Despite the fact that this model has been seen in a number of nations, Ghana may offer the best illustration of its dynamics given to the extensive mechanization-focused research that has been done there. The IFPRI/SARI survey in Northern Ghana offers an overview of tractor ownership, service offering, and hiring in Table 1. As can be seen, even very large farmers are motivated to rent out their tractors at prices comparable to other farmers because they often do

not produce enough land to match a tractor's seasonal utilization capacity. The provision of plowing services is a significant source of income for all three types of owners, though overall profitability increases when plowing services are combined with other services like maize transport and shelling, as well as the advantages of timeliness gained by avoiding the delays brought on by hiring in services, as opposed to owning a tractor.

In a JICA survey conducted in three communities in Northern Ghana, for instance, 16% of rice farmers who requested tractor services did so within the first week following rain, 47% did so within the next two weeks, and 82% did so within the next three weeks. Tractor hire is nevertheless likely to be appealing because to its labor-saving advantages and may still make plowing possible more quickly than it may be using manual labor or animal traction, even though hiring market delays may arise.

Table 1: Summary of Tractor Ownership and Services from 2013 IFPRI/SARI survey in Northern Ghana.

	Small (<5 ha)	Medium (5-20 ha)	Large (>20 ha)
% owning tractor	3.8	25.1	71.1
Land owned (ha)	5.3	16.5	61.6
Area cultivated (ha)	2.9	9.5	38.4
% of total owners	7.2	53.0	39.8
Tractors per owner	1.1	1.1	1.3
% of owners hiring out services	88.9	87.6	89.0
Mean area plowed on own farm (ha)	4.1	10.8	33.6
Mean area plowed on others' farms (ha)	188.2	167.4	199.6
% of farmers hiring in any services	48.6	59.4	43.5
% of farmers hiring in first plowing services	44.3	48.2	22.2
% of farmers hiring in maize shelling	17.2	30.5	28.9

Evidence from mostly rain-fed regions in Ghana indicates that tractors were profitable investments for 54% of questioned owners when considering only the supply of plowing services, and profitable for 85% of surveyed owners when taking into account all of these characteristics. For owners' investments to be lucrative, particularly for medium-sized farmers, hiring out services is frequently necessary. This suggests that the number of owners is limited by the ability of the potential owners to find enough other farmers as consumers of their services, an indication that the service market is rather competitive and that service prices are primarily set by the market rather than monopolistically by the service providers. Figure 1 compares the profitability of tractor ownership between offering solely plowing services and also taking into consideration the advantages of offering shelling services and minimizing the risk of delays. These extra factors make it much simpler to reach the necessary breakeven acreage and increase revenues, which explains some of the benefits of farmer tractor ownership above that of specialized tractor service businesses [8], [9].

Along with the prevalence of tractor rental services in rainfed agriculture, irrigated agricultural systems have seen a considerable increase in mechanical field preparation and harvesting, including both land preparation and harvesting, across Africa. In Ghana, more than half of the areas within three of the five main irrigation projects are now plowed by privately hired tractors or power tillers. Power tillers, which are mostly utilized for rice farming in the Kpong Irrigation

Scheme, have comparable utilization trends to 4-wheel tractors observed in other places. Although approximately half of the owners surveyed said they bought their power tillers from the private sector, there were notable discrepancies in the profitability of machines bought through government and private channels. Owners surveyed who purchased their equipment through private channels had average annual earnings of $542, compared to annual losses of $311 for those who bought their power tillers from the government or non-profit organizations. This significant disparity shows that additional efforts are needed to direct subsidies to owners who could profitably use the equipment. Recently, hiring services for combine harvesters have also begun to grow in favor in West African irrigation projects. Similar to this, the Bakolori irrigation scheme, the largest scheme in Nigeria, covers more than 70% of the region using tractors and mechanical threshers, largely through commercial service providers [10].

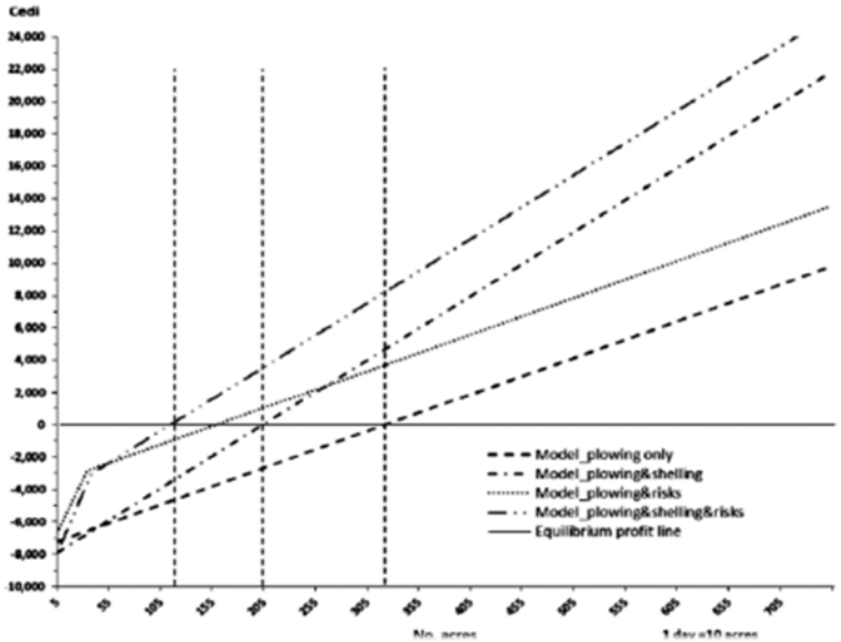


Figure 1: Net used tractor mechanization service profits under four scenarios, Ejura District, Ghana.

DISCUSSION

According to a general conclusion reached from the most recent research, there is now insufficient supply of tractor services for plowing in Ghana, Nigeria, and possibly other regions of Africa. In Ghana, a poll of service providers found that over half of them felt they cannot satisfy demand, while only around half of them said that their tractors were being used to their maximum potential. Long travel times to clients and frequent breakdowns are mentioned as other significant obstacles for tractor owners to overcome in order to fully utilize their vehicles. It is also assumed that there aren't enough medium-sized and large-scale farmers in Nigeria who possess tractors to supply the needs of smallholders. It may be demonstrated by the variations in plowing fees between nations and between regions within nations that the markets for renting tractor services are very localized, revealing price discrepancies in various places. Significant regional and even district-level disparities in service costs between nations may be due to regional variations in the demand for mechanization services and tractor density. With

the exception of Zambia, where tractors are more often utilized on remote commercial farms, nations with higher overall tractor density actually have lower hiring costs on average. Such patterns are particularly evident in Ghana, Nigeria, and Mozambique, where dramatic differences in tractor use within agro-ecological zones and between regions with varying degrees of economic development have been noted.

Given that practically all land preparation in most Asian nations has been automated through a very small group of owners leasing out services, it is probably unnecessary for there to be many tractor owners in a region. There is little evidence to suggest that the current hiring market is not competitive enough at the given level of tractor owners, even though the presence of sufficient numbers of tractor owner-operators may assist make service rates for smallholders more reasonable. It is also unclear how much service fees account for the expenses that tractor owners must bear, such as the cost of the tractor, gasoline, maintenance, and operator salaries, as well as how much they account for farmer demand.

The limitations on tractor mobility may contribute to differences in plowing service fees and the difficulty in some places of obtaining such services. The size of tractors, the road network and road condition, as well as the development logistics of shipping tractors across regions, are all significant barriers to migration. While cross-regional migration has been observed for a few owners in some areas of Ghana, Nigeria, and Ethiopia, increasing profitability for owners and improving the overall efficiency of hiring service markets, as well as the size of tractors, are all factors affecting migration. Migration does not yet appeal to many tractor owners, but it does appear to be beneficial overall for the service providers who execute it. Table 1 shown the plowing costs in selected countries and regions.

Table 1: Plowing Costs in Selected Countries and Regions.

	Burkina Faso	Ethiopia	Ghana	Kenya	Mozam-bique	Nigeria	Rwanda	Tanzania	Zambia
Cost of plowing 1 ha (USD)	51	81.25	46	31.25 gov; 50 private	62	60	163	68	125
Ghana	Ejura		Gushiegu		Yendi		Sissala East		
Cost of plowing 1 ha (USD)	53.97		41.36		43.83		60.35		
Nigeria	North East		North West		North Central		South East		South West
Cost of plowing 1 ha (USD)	93.75		42.75		44.53		74.38		42.58
Mozambique	Masssingir	Chókwè	Manica		Sofala	Zambezia	Gurue		Nampula
Cost of plowing 1 ha (USD)	45-55	61-91	61		55	62-75	70		55

In Ghana and Nigeria, the vast majority of tractor owners offer services in their local communities. The IFPRI/SARI survey reveals that approximately one fifth of tractor service providers migrated to between north and transition zones to provide plowing services in Ghana, where there is one crop season in the north and two crop seasons in the transition zone that is not too far from the north. The vast majority of the migratory service providers are concentrated

in one district. Similar to this, survey respondents who own tractors in Nigeria's Kaduna and Nasarawa states may travel to perform services but are not likely to move between agro-ecological zones. During the busiest time of the year for plowing, most owners operate within 25 to 30 kilometers of their homes, with just around 12% of all plowing occurring outside of the state where the owner resides.The migration model is vital and more appropriate for mechanized harvesting, which also needs smaller machinery and decent roads , according to the experiences of the Asian countries, even though it is less common in Africa. Other factors, such as making tractors multifunctional, could increase the profitability of tractor owners.

The inherent cap on how often a tractor can be used for plowing also suggests that the most effective way to promote tractor ownership is to minimize the investment cost. The policy conundrum at hand concerns whether or not initiatives to reduce tractor investment costs are sustainable and do not involve "winner picking," a crucial subject that we will cover in more detail in the report's policy section. For combine harvesters, services are offered from farmer to farmer. However, there is not enough data to determine the effectiveness of this strategy because there are so few extremely large farmers who buy such expensive machinery. In a survey of medium-sized to large-scale farmers in Ghana, for instance, only 2% of farmers reported using combine harvesters, but 30% said they wanted to buy one. Smaller farms in Africa may benefit from using little combines, which have been successfully utilized in Asia. However, they work better in wheat-barley systems than the maize systems that are prevalent throughout most of Africa. In some regions of Kenya, where mechanized harvesting is in demand among smallholders because it is less expensive and quicker than manual harvesting and where owners have excess machine capacity, services involving combine harvesters are frequently contracted.

Combination harvesters were employed by a sizeable portion of farmers in the area where the prerequisites were met. For instance, in the Asasa and Etheya districts of Ethiopia's Arsi region, in 1995, 78% and 59% of farmers, respectively, used combine harvesters, primarily through private owners. Small-scale farmers frequently banded together to satisfy the cost and scale requirements for accessing combine harvester services, suggesting that the field needed to be connected and free of obstructions to a combine's movement. However, employing human harvesting labor is about 20–30% more expensive in these regions than utilizing a combine. Although government hire services and state farms were also active in the region until recently, private machine owners provide the majority of services to farmers. A large cluster of market-oriented producers with a need for harvesting and threshing services helps owners get around the difficulties of traveling to service small farms but physically connected in West Africa, where there are also active hiring markets for combine harvesters and threshers. For instance, the Kpong Irrigation Scheme in Ghana uses combines to harvest 48% of its rice fields, and nearly all of its farmers are small-scale.

In both rice irrigation schemes and other rainfed cereal systems, the service provision of mechanical threshing is significantly more widespread in cereal systems. In Ghana, where maize shelling is a significant expansion of tractor use, the IFPRI/SARI study of medium-to-large farms found that 25% of farmers employed tractor-driven maize shelling services. According to an assessment of irrigation schemes, 68% of the rice in Senegal is mechanically threshed . Although prices are thought to be high due to limited access to threshing technology,

service provision for rice, wheat, and maize threshing using locally made threshers is also widespread in various parts of Ethiopia as demand for mechanized threshing rises.

CONCLUSION

Farmer ownership traits significantly impact agricultural systems and outcomes. Factors such as farm size, education, experience, and resource access influence decision-making, productivity, and sustainability. Farmers with more land and better access to resources can invest in advanced tools, gear, and equipment, while smallholder farmers often face resource limitations and rely on conventional methods. Education and experience also influence farmer ownership, with higher-educated and well-trained farmers adopting innovative practices, using sustainable methods, and making wise choices about inputs, crop management, and market prospects. Access to resources, such as loans, inputs, and market intelligence, also influences farmer ownership. Smallholder farmers may struggle to invest in new technology or expand their businesses due to limited resources, while those with more resources have more flexibility and growth options. Understanding these aspects is crucial for establishing targeted interventions, policies, and support systems to improve production, profitability, and resilience.

REFERENCES

[1] C. Rigal, P. Vaast, and J. Xu, "Using farmers' local knowledge of tree provision of ecosystem services to strengthen the emergence of coffee-agroforestry landscapes in southwest China," PLoS One, 2018, doi: 10.1371/journal.pone.0204046.

[2] V. Gramm, C. D. Torre, and A. Membretti, "Farms in progress-providing childcare services as a means of empowering women farmers in South Tyrol, Italy," Sustain., 2020, doi: 10.3390/su12020467.

[3] E. Smith Dumont, G. M. Gnahoua, L. Ohouo, F. L. Sinclair, and P. Vaast, "Farmers in Côte d'Ivoire value integrating tree diversity in cocoa for the provision of ecosystem services," Agrofor. Syst., 2014, doi: 10.1007/s10457-014-9679-4.

[4] H. S. Kassem, R. M. Shabana, Y. A. Ghoneim, and B. M. Alotaibi, "Farmers' perception of the quality of mobile-based extension services in egypt: A comparison between public and private provision," Inf. Dev., 2020, doi: 10.1177/0266666919832649.

[5] L. S. O. Liverpool-Tasie et al., "A scoping review of market links between value chain actors and small-scale producers in developing regions," Nat. Sustain., 2020, doi: 10.1038/s41893-020-00621-2.

[6] S. D. Tumbo, N. Mwalukasa, K. G. Fue, M. R. S. Mlozi, R. Haug, and C. A. Sanga, "Exploring information seeking behavior of farmers' in information related to climate change adaptation through ICT (CHAI)," Int. Rev. Res. Open Distance Learn., 2018, doi: 10.19173/irrodl.v19i3.3229.

[7] C. R. Cerdán, M. C. Rebolledo, G. Soto, B. Rapidel, and F. L. Sinclair, "Local knowledge of impacts of tree cover on ecosystem services in smallholder coffee production systems," Agric. Syst., 2012, doi: 10.1016/j.agsy.2012.03.014.

[8] B. K. Bani and L. Damnyag, "Farmers' Willingness to Pay for the Provision of Ecosystem Services to Enhance Agricultural Production in Sene East District, Ghana," Small-scale For., 2017, doi: 10.1007/s11842-017-9364-3.

[9] C. Jack, A. H. Adenuga, A. Ashfield, and M. Wallace, "Investigating the drivers of farmers' engagement in a participatory extension programme: The case of Northern Ireland business development groups," Sustain., 2020, doi: 10.3390/su12114510.

[10] G. N. Njurumana, K. L. Ginoga, and D. Octavia, "Sustaining farmers livelihoods through community forestry in Sikka, East Nusa Tenggara, Indonesia," Biodiversitas, 2020, doi: 10.13057/biodiv/d210846.

CHAPTER 8

ROLE OF GOVERNMENT IN PROMOTING MECHANIZATION

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

The government plays a crucial role in supporting agricultural mechanization, which is essential for increasing agricultural output, lowering labor costs, and boosting sector efficiency. To foster an enabling environment, governments can provide financial incentives, subsidies, and loans to farmers and agribusinesses for the acquisition of machinery and equipment. Reducing import taxes or tariffs on agricultural machinery can make mechanization more accessible and inexpensive. To promote creativity and adapt mechanized technology for regional agricultural conditions, governments can invest in research and development, working with research organizations, agricultural universities, and commercial sector entities. They can also offer training and capacity-building initiatives for farmers, equipment operators, and service providers, improving understanding of mechanized technologies, encouraging correct use and maintenance, and guaranteeing optimal results. Establishing cooperatives or mechanization service centers can provide common access to machinery and equipment, lowering entry barriers and supporting equitable resource distribution. Government interventions should focus on infrastructure development, particularly rural roads and access to energy sources, to enhance transportation and operation of machinery in remote locations.

KEYWORDS:

Farm Equipment, Technology Adoption, Agricultural Policies, Government Support, Mechanization Programs, Farming Productivity.

INTRODUCTION

As has been shown, there is a growing need for mechanization across many sectors in African nations, and in recent years, the private sector's channels for machine purchases and the delivery of mechanized services have expanded. However, there are other methods for governments to assist in the mechanization process, including investing in public goods, creating a supportive political environment, and offering capacity-building and technical assistance where necessary.

Providing Public Goods to Create an Enabling Environment for the Private Sector

Numerous African governments have frequently believed that getting directly involved in mechanization is an efficient method to advance mechanization. Governments frequently hold the view that although private sector-led mechanization takes place in their nations, its scope is frequently too limited and its pace is too sluggish for the majority of smallholders to adopt the technology. It is difficult that a government will refocus its activities in fostering true private sector-led mechanization without taking into account the whole competitive advantage of the private sector along the supply chain. Governments can play a bigger part in producing and distributing public goods that the private sector urgently needs if they concentrate on the

role in creating an environment that allows the private sector to lead mechanization. These public goods include the dissemination of information about machines, how to operate machinery, farming methods that can maximize the benefits of mechanization, and to support the creation of institutions that are ideal for supplying such public goods [1], [2].

Research on Mechanization Demand and Adoption

Strengthening research on the scope and character of mechanization adoption would be one such public good. Because of this limited nature of the demand for mechanization, which was covered in Section 3, it is difficult to draw conclusions about the most practical locations for mechanization. In order to better understand the nature of demand for mechanization services based on various farming systems, labor dynamics, and socioeconomic considerations, study must be intensified. Governments might address this data gap by conducting household surveys and tractor censuses that accurately reflect the dynamics of equipment ownership, use, and service provision across various geographic and climatic regions. Additionally, information on the types of tractors required and the results of plowing can be found on soil maps. This can be used to determine the locations that should receive priority for mechanization as well as those where population and market factors have not yet made mechanization possible [3], [4].

Support R&D

Government funding for R&D will be crucial in nations where the pursuit of the manufacture of machines, implements, and replacement parts is being sought, in addition to the collection and analysis of data on the use of mechanization. By creating locally accessible equipment that may be more suited for African farmers than the huge 4-wheel tractors that now rule the market, such support can also address the issue of appropriate technology. There have been instances of productive cooperation between national research institutions and outside agencies, including with the ASI thresher in Senegal. If the innovations created are to be more appropriate for local conditions while yet being competitive with imports, such cooperative efforts may be required. Increased funding, collaboration with manufacturers in Europe and Asia to learn from and adapt equipment created there, and facilitation of South-South knowledge exchanges for agronomists and agricultural engineers are all ways that governments can further boost R&D activities. Such initiatives would be a reflection of the enormous research being conducted in the seed industry. Lessons can be learned from India and China, who have encouraged the production of agricultural machinery by providing public subsidies for a variety of equipment. Such initiatives ought to be conducted in a way that complements current private sector research on machinery design advancement, which is frequently carried out by regional fabricators.

Experiences regularly seen in Asian nations demonstrate the necessity of multi-functional tractor use for wide-scale adoption in agriculture. Tractor innovation, which is necessary to make them more useful and multifunctional in today's Africa, is probably only possible in the private sector. The support of the public sector in promoting the use of multi-functional tractors may motivate the private sector to provide the right equipment and technology, which will greatly enhance the usage of tractors beyond plowing. To enable farmers to use tractors and power tillers in numerous ways, however, could require some work.

Owners and mechanics would also benefit from technical instruction in fundamental tractor operations, adapting tractors to various soil and agro-ecological conditions for various crop

systems, and machine maintenance and repair. For instance, in Ghana, the majority of operators have no formal training and no driving privileges; instead, they learn by helping other tractor drivers. The majority of mechanics are improvised roadside mechanics who frequently try repairs utilizing improvised spare parts through trial and error. To improve operating efficiency, however, aid organizations like JICA and tractor manufacturing firms have prioritized training programs for tractor owners, operators, and mechanics (JICA 2014). Additionally, commission-based operators who do not own the equipment typically have no motivation to keep it in good working order and instead overuse it. Tractor operators must, however, complete specialized training in order to obtain licenses in Ethiopia. A regulation like that might stop operators from abusing equipment. Business-development services could help owner-operators increase the effectiveness of their hiring out businesses in addition to technical skill training. Such training initiatives have been carried out by FAO, mostly in East Africa for conservation agriculture equipment. Where local extension networks have been successful, including such trainings for tractor owners may be a good use for them [5].

Success Story: Prudent use of Government Subsidies to Promote Mechanization

The Indian government generously supports the manufacturing and agricultural industries, especially by offering subsidies for mechanization tools. These subsidies seem to have promoted mechanization while avoiding some of the inefficiencies that affected the subsidies provided by African countries. To guarantee that the types of machines being adopted were driven by choice rather than the subsidy, India's subsidies included a wide range of equipment, including tractors of various sizes, power tillers, reapers, transplanters, and animal-drawn equipment. Smaller tractors have recently been covered by subsidies, allowing smaller-scale farmers to buy them and offer tractor-hire services. Additionally, extensive state investment in R&D and the provision of long-term loans, primarily for the acquisition of machinery, have supported these subsidies. Therefore, African nations have role models to follow for encouraging private importation as well as making public importation beneficial rather than constrictive [6], [7].

Infrastructure Investments

Government investments in regional and national road systems can also help with the delivery of mechanized services. The area that machines can plow will increase as a result of reduced travel time between fields made possible by improved road infrastructure in rural areas. Cross-regional migration would be facilitated by improvements to the national road networks. Better rural and feeder roads will also make it simpler for tractors to transport both agricultural and non-agricultural items throughout the year in rural regions. Improved market access and increased labor mobility may result from better rural roads, which may also encourage additional labor migration away from agriculture and increase the demand for mechanization.

Mechanization Credit Schemes

A number of governments have launched lending programs to enable more farmers to buy mechanization equipment and offer hiring services, frequently in partnership with donors. These programs frequently focus on apparatus that governments consider to be better suited for farmers. In an effort to solve this problem, government and donor projects in Mozambique, Tanzania, and Zambia have offered enticing lending terms for individual farmers and cooperatives to purchase tractors and offer services to smallholders (World Bank 2014b).

Programs in Tanzania include the Agricultural Inputs Trust Fund, which gives money to individual farmers for 4- and 2-wheel tractors as well as other agricultural inputs, and District Agricultural Development Plans, which offers an interest-free loan to farmer groups for the acquisition of 2-wheel tractors. Importers and farmers can obtain government-backed funding through the Tanzania Investment Bank's agriculture window (CIMMYT 2015). Nigeria's government is working to implement NIRSAL (Nigerian Risk-Sharing Agricultural Lending), which will guarantee up to 75% of bank loans for mechanization and other agricultural investments and may open the market to more private tractor imports as the federal government seeks to reduce its involvement (World Bank 2014a). This program will complement the subsidized credit made available by the AEHE program in Nigeria. In the past, low repayment rates and excessive monitoring expenses have hurt numerous government mechanization credit initiatives. As a result, they might not be a workable or long-term solution to the possible service providers' lack of interest in machine purposes. Due to high monitoring expenses, loan guarantees made through NIRSAL in Nigeria may be subject to moral hazard on the part of both banks and borrowers. There are also worries that certain conditions-attached subsidies and subsidized lending will distort import markets. It remains to be seen, however, whether such schemes would prove to be sustainable or fail due to subpar administration and high default rates, similar to the AMSEC scheme in Ghana [8], [9].

DISCUSSION

Eliminating Distortions

Governments may feel forced to actively promote mechanization technology despite being aware of the potential distortionary impacts of subsidies. Many governments have acknowledged the validity of farmer-to-farmer service delivery and agreed that potential owners of machines are prevented from purchasing them due to high upfront costs and a lack of accessible finance. In these situations, providing credit or granting tractor subsidies may encourage more large and medium-sized farmers to purchase tractors and offer their services. Such a strategy, nevertheless, should only be used in situations where it is certain that there is a high demand for hiring in the services and should promote a positive atmosphere as opposed to competing with, distorting, or displacing the private sector. As mentioned in earlier sections, subsidized service provision and machinery subsidies that have a negative impact on private importers and unduly influence brand choice are both examples of distortionary impacts that should be avoided.

Another area where inefficiencies influencing mechanization can be eliminated is trade and fiscal policy. Burkina Faso and Mozambique are the two exceptions in the World Bank's ABI case studies, charging a 5% import charge, which can reach up to 16% in practice in the former (World Bank 2013b; 2013c). The majority of African nations have reduced import duties and VAT for imported tractors. Tractors in Ethiopia are only excluded if they are cleared and acquired within six months of their arrival at the port of Djibouti, which is a more complicated process (World Bank 2012a). However, imports of spare parts are still subject to high taxes that can reach 30% in many nations. As a result, sufficient inventories cannot be created and provided to customers, which causes considerable delays when a breakdown happens during the busiest time of the year. The full tariffs are still frequently applied to raw materials for mechanization implements and completely- and semi-knocked-down (C/SKD) tractor parts (World Bank 2014b). Governments could support this by abolishing or decreasing taxes on raw

materials for CKD parts if locally produced implements or locally assembled tractors have a chance to compete with imports. The timely supply of machinery to rural areas can also be negatively impacted by delays in import procedures. For instance, CAMARTEC, the government organization in charge of machinery quality monitoring and testing, must inspect and authorize all machinery imported into Tanzania. A number of stakeholders have identified delays in this process as a significant obstacle, despite the fact that this helps ensure that only well-functioning devices enter the nation (World Bank 2012c). In other words, import regulations should not only give importers, and subsequently users, incentives, but also make sure that testing and customs procedures go smoothly to prevent delays.

Success Story: Creation of an Enabling Environment for Private Sector Driven Mechanization

While government imports occasionally have the potential to choke off private supply chains, they can also act as a catalyst for increased importation. For an example, it's often believed that Bangladesh's transformation from a "basket case" to one with over 80% mechanization of main tillage operations resulted from the relaxation of limitations on Chinese 2-Wheel tractors. President Ershad was encouraged to remove import restrictions on Chinese 2-wheel tractors by the national standards committee after a string of devastating floods and storms in the late 1980s wiped off the nation's population of draught animals (Biggs et al. 2011). Due to this, the price of imported machinery was reduced by 40%, and numerous of these tractors were imported in the middle of the 1990s. As discussed throughout this paper, as a result, land preparation is now largely mechanized, with 2-wheel tractors providing 92% of all tractor power [10]. Table 1 shown the import duties and VAT for Tractors and Parts in selected Countries.

Table 1: Import duties and VAT for Tractors and Parts in selected Countries.

	Burkina Faso	Ethiopia	Ghana	Kenya	Mozambique	Nigeria	Rwanda	Tanzania
Import duty + VAT for tractors	16%	0%	0%	0%	5%	0%	0%	0%
Import duty + VAT for spare parts	20%	25-40%	27%	16%	25%	5%	30%	10%

The full tariffs are still frequently applied to raw materials for mechanization implements and completely- and semi-knocked-down (C/SKD) tractor parts (World Bank 2014b). Governments could support this by abolishing or decreasing taxes on raw materials for CKD parts if locally produced implements or locally assembled tractors have a chance to compete with imports. The timely supply of machinery to rural areas can also be negatively impacted by delays in import procedures. For instance, CAMARTEC, the government organization in charge of machinery quality monitoring and testing, must inspect and authorize all machinery imported into Tanzania. A number of stakeholders have identified delays in this process as a significant obstacle, despite the fact that this helps ensure that only well-functioning devices enter the nation (World Bank 2012c). In other words, import regulations should not only give importers, and subsequently users, incentives, but also make sure that testing and customs procedures go smoothly to prevent delays.

Potential Roles of Donors in Mechanization Promotion

The roles of donors in advancing mechanization should be comparable to those of governments, with a focus on boosting farmer demand and bridging supply chain gaps by fostering private sector growth. They should also refrain from initiatives that would stifle the market for goods and services, such direct subsidies. In fact, donors paid for a large number of the famously ineffective government mechanization systems (Tokida 2013, in Kienzle et al 2013). Instead, training and capacity development throughout the mechanized supply chain should be the focus of donor assistance. Support for regional R&D and production, as well as the presentation of possibly more efficient technologies and instruction for farmers, can all fall under this category. For instance, JICA has supported R&D initiatives in African universities, facilitated South-South trainings, and supported a variety of other technical cooperation projects, with a particular focus on rice mechanization, in addition to the provision of machinery through 2KR grants in order to improve the utilization of agricultural machinery. General farm mechanization, upland and irrigated rice mechanization, creation of suitable technology for small-scale farmers, testing and evaluation of machinery, repair and maintenance, and rice postharvest and processing technologies have all been covered in specific trainings. According to Tokida (2013) in Kienzle et al (2013), these trainings have long been held in nations such Egypt, Morocco, Tanzania, Ghana, Cote D'Ivoire, and Madagascar, among others. In addition, the Japanese Association for International Collaboration of Agriculture and Forestry (JAICAF) is training farmers in Ethiopia, Uganda, and Tanzania on a variety of technology, such as tractors, power tillers, rice seeders, and rice mills. While interventions like subsidized machinery and service provision may skew private supply chains, such support boosts demand for and improves usage of agricultural machinery. However, all mechanized initiatives should be planned with the intention of gradually ceasing once a more robust private supply chain has been established.

Opportunities for Private-Sector Promotion of Mechanization

The private sector, defined broadly to include small businesses, major corporations, and individual farmers, has been extensively explored as being in the greatest position to respond to the growing need for automation as a result of intensification processes. There is still a "business case" to be made, nevertheless, for the private sector to support mechanization. This "business case" depends on both active government efforts to produce public goods and on avoiding ineffective direct engagement. This entails businesses actively attempting to overcome the lack of information among farmers and the failure of the financing market, two major market failures in mechanization.

Demonstration projects may assist in introducing farmers to new technologies and exposing them to existing ones when they have not yet been widely adopted if the lack of knowledge regarding the availability and usage of mechanization equipment is a significant limitation for farmers. Similar to the John Deere situation in Zambia that was discussed in the section before, manufacturers have invested in training facilities and other initiatives to introduce farmers to various types of machinery and to provide them with the technical and managerial training necessary for successful ownership. These business-focused trainings put a special emphasis on providing services from farmer to farmer, as tractor manufacturers have started to realize that such a model might encourage more farmers to invest in their equipment. If supporting supply networks for spare parts and repairs could also be built, demonstration of the entire

range of machinery on the market might also assist in correcting distortions introduced by subsidies or concessional loans that limited farmers' exposure to select brands. However, there is a dearth of actual data in this field. It shouldn't be assumed that most farmers are ignorant of the advantages of different forms of mechanization. To determine when the demand for mechanization can be sparked by alerting farmers of the possible benefits, more pilot studies together with thorough assessments may be required. The long-term viability of the financing offered by manufacturers and dealers is also still up in the air.

African agricultural and economic change is anticipated to be aided by increasing the usability and efficacy of agricultural mechanization. Mechanization still has to get past the past, which is rife with poorly thought out projects that didn't consider demand, relative neglect by researchers and policymakers, and false notions about what mechanization is and isn't. This background paper has made an effort to provide a clear and comprehensive definition of mechanization, identify the factors that influence demand for mechanization, describe the patterns of mechanization that have started to appear throughout Africa using a supply-chain approach, and highlight the key roles played by the government in promoting mechanization.

Several myths have harmed the discussion about mechanization. When people think about mechanization, they frequently picture huge tractors working on expansive fields or industrial estates. However, all sizes and types of farmers in Africa have access to mechanization equipment in many farming systems, whether they own the equipment themselves or use the services of other owners. Furthermore, mechanization is crucial for a number of agricultural tasks, including the most important ones like threshing, harvesting, and land preparation, as well as for non-agricultural tasks like rural transportation and road building. Misconceptions abound regarding the usefulness of mechanization.

On the one hand, during the 1960s and 1970s, it was occasionally marketed indiscriminately, even in regions where farming systems had not yet developed to the point where demand among farmers existed. On the other side, forced automation is sometimes linked to environmental degradation and the eviction of tenant farmers and rural laborers. There is little evidence that either of these is happening in Africa; instead, mechanization is more likely to lead to an increase in overall labor demand when it makes it possible to cultivate more land and is frequently combined with other techniques aimed at preserving soil fertility. The level of farming system intensity, market access for agricultural goods, wage dynamics, the availability of complementing technologies, and the ability to fully utilize machinery all influence the demand for mechanization.

Mechanization is a part of the agricultural intensification process and cannot be used to start it if it is not already being driven by population pressure and market demand, as Boserup theorizes and as a number of previous mechanization programs failed to recognize. The principles behind the intensification processes taking place in Africa could be similar to those of the Asian Green Revolution. However, the processes vary quite a bit between and within nations, depending on factors like population density, market accessibility, agro-ecology, and others. Therefore, there is a substantial regional difference in mechanization demand across Africa, which requires better statistics and more information to be captured. However, it does seem that there are some areas where smallholder farmers have developed a strong demand.

Private market channels have proven they can satisfy mechanized demand where it exists. Private importers are able to bring in less expensive machinery from the manufacturers that farmers favor since their spare parts and repairs are easier to get. Farmer to farmer service delivery also has inherent advantages over other models because owner-operators can generate income from hiring out in addition to benefits for their own farms without the administrative expenses and other inefficiencies that, even when subsidized, are faced by specialized hiring services. These channels of supply are still not ideal, and the availability of services to additional smallholders depends on the desire of large and medium farms to acquire tractors that may be employed in the market for service hiring.

Many variables influence these farmers' motivations to purchase tractors, including the fact that spare parts and repair service networks are still insufficient and borrowing rates are frequently too high for many potential buyers to obtain financing. It is frequently inefficient to supply mechanization through improper government intervention, which can have a negative impact on the growth of the private supply chain. While subsidies may be required in some circumstances, they can also limit access to technology and brands that are better suited for the country and drown out private employment services. If government subsidies are deemed necessary, they should be designed to reach farmers who can use equipment effectively and provide services, cover a wide range of brands and machines to accommodate farmers' needs and preferences, and have a phase-out strategy after boosting private demand.

Governments can encourage mechanization by fostering an atmosphere that allows commercial supply chains to continue satisfying farmers' desires for automation. The provision of public goods, such as key knowledge and R&D, encouraging innovation in the use of multifunctional tractors, capacity building activities, like training and study tours, creating incentives for private importation and service provision, and making any involvement coherent and transparent through an efficient national strategy are a few actions that governments can take. Additionally, there is a need for governments and international organizations to perform in-depth, locally focused research that accurately assesses demand for mechanization products and services in each farming system while also capturing the dynamics of mechanization use.

CONCLUSION

Government promotion of automation is essential for supporting economic growth, raising productivity, and raising standard of living in general. Governments can promote the widespread use of automated systems across numerous industries by enacting supportive legislation, offering incentives, and establishing a conducive atmosphere for technical improvements. This covers sectors including manufacturing, transportation, agriculture, and infrastructure. Mechanization aids in streamlining procedures, reducing manual labor, increasing productivity, and improving efficiency, which promotes economic growth and increases competitiveness. Government intervention can also alleviate possible problems brought on by mechanization, such unemployment, by funding retraining programs and assisting workers in switching to new industries. Overall, utilizing the advantages of technology to promote growth and prosperity depends critically on the government's involvement in fostering mechanization.

REFERENCES

[1] A. K. M. S. Islam, "Status of rice farming mechanization in Bangladesh," J. Biosci. Agric. Res., 2018, doi: 10.18801/jbar.170118.171.

[2] K. Sharma and H. P. Mathur, "A Step Towards Digital Agronomy by Startups," Int. J. Bus. Insights Transform., 2019.

[3] E. T. Quartey and S. Darkwah, "Factors affecting the use of modern technologies in Agro processing in Ghana," Acad. J. Agric. Res., 2015.

[4] A. K. Srivastava, "Role of institutional credit for agricultural development in Bihar," J. Rural Dev., 2017, doi: 10.25175/jrd/2017/v36/i1/112700.

[5] X. Diao, J. Silver, H. Takeshima, and X. Zhang, "An evolving paradigm for Africa and synthesis of the lessons from Asia," in An evolving paradigm of agricultural mechanization development: How much can Africa learn from Asia?, 2020.

[6] E. Li, M. Yang, and M. L. Cook, "Agricultural machinery cooperatives in China: Origin, development, and innovation," in American Society of Agricultural and Biological Engineers Annual International Meeting 2009, ASABE 2009, 2009. doi: 10.13031/2013.27292.

[7] P. Vantomme, E. Mertens, A. Van Huis, and H. Klunder, "Assessing the Potential of Insects as Food and Feed in assuring Food Security: Executive Summary," Tech. Consult. Meet., 2012.

[8] B. Pan and Z. Tian, "Mechanism of factor substitution during rapid development of China's agricultural mechanization," Nongye Gongcheng Xuebao/Transactions Chinese Soc. Agric. Eng., 2018, doi: 10.11975/j.issn.1002-6819.2018.09.001.

[9] R. M. Lantin, "Industrialization and tourism as strategies for promoting agricultural and fisheries mechanization in the Philippines," AMA, Agric. Mech. Asia, Africa Lat. Am., 2013.

[10] X. Chen, H. Wen, W. Zhang, F. Pan, and Y. Zhao, "Advences and progress of agricultural machinery and sensing technology fusion," Smart Agric., 2020, doi: 10.12133/j.smartag.2020.2.4.202002-SA003.

CHAPTER 9

A BRIEF STUDY ON CONTEXT OF AGRICULTURAL MECHANIZATION

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

Modernizing and enhancing agricultural processes heavily relies on agricultural mechanization. It entails the adoption and use of machinery and equipment to carry out a variety of farming tasks, including the preparation of the land for planting, harvesting, and processing after the harvest. In the context of agriculture, mechanization is used to address issues including labor shortages, low productivity, and the necessity for environmentally friendly farming practices. Governments, agricultural groups, and farmers seek to improve total agricultural outputs by supporting and facilitating mechanization in order to raise production, decrease drudgery, and increase efficiency. Farmers may do jobs more quickly and accurately when they use mechanized equipment, which results in higher yields, better crop quality, and enhanced profitability. Additionally, the use of precision farming methods like GPS technology and sensors to maximize resource efficiency and reduce environmental effect is supported by agricultural mechanization. But in the context of agricultural mechanization, it's also important to address possible downsides, like the equipment's high initial price, accessibility to credit, and the need for training so that farmers can use it to its full potential. In general, agricultural mechanization is concerned with using technology to solve problems in agriculture and establish productive and sustainable farming methods.

KEYWORDS:

Agricultural Mechanization, Farmer Services, Farm Equipment, Hiring Market, Mechanization Strategy.

INTRODUCTION

On September 25, 2015, the United Nations General Assembly (UNGA) formally accepted the 17 Sustainable Development Goals (SDGs), bringing them into existence. With its knowledge and resources, the Food and Agriculture Organization of the United Nations (FAO) is well positioned to assist nations, particularly those in Africa, in attaining the SDGs; we must seize this chance to become Generation Zero Hunger. Agricultural mechanization is crucial to this development process, and FAO's work on sustainable production intensification and creating green food value chains (FAO, 2014a) will be a component of this endeavor as display in Figure 1 [1].

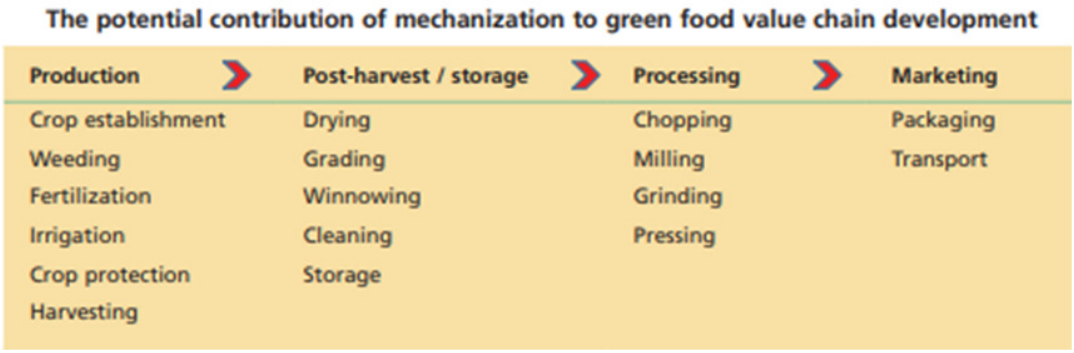


Figure 1: The potential Contribution of Mechanization to green food value chain development.

Agricultural mechanization for the vast majority of smallholder farmers in sub-Saharan Africa (SSA) has unquestionably been a neglected subject for far too long. Farm mechanization, or the application of farm power to suitable tools, implements, and machines, is a crucial agricultural input that has the potential to drastically change the livelihoods of rural families by enabling increased output of higher value products while eradicating the tedium associated with human muscle-powered agricultural production. Smallholder farmers might benefit from access to input supply chains and integration into contemporary food systems, which would increase their income, open up new business prospects, and allow for further value addition. Additionally, agricultural mechanization in its broadest sense has the ability to make post-harvest, processing, and marketing operations and functions more effective, efficient, and environmentally friendly, which can have a substantial impact on the development of food systems [2].

The primary justifications given by FAO (2014b) for switching from human or animal muscles to tractors as the source of power for crop production are as follows:

i. The potential to increase the land that is being farmed.

ii. The capacity to execute tasks at the optimal moment to optimize production potential.

iii. Tractors can be used for transportation, stationary power applications, and infrastructure enhancement drainage and irrigation canals, road work, etc. in addition to crop cultivation.

iv. Paying for seasonal labor shortages or, more accurately, freeing up labor for more fruitful tasks.

v. Reducing the tedium involved with using human physical strength for chores like hand hoeing for primary tillage. This is particularly crucial in tropical regions where high heat and humidity which are occasionally linked to low nutrition make manual labor incredibly taxing [3].

Despite these alleged advantages and the fact that tractors had largely replaced livestock in Western Europe and the United States by the 1950s, care was still advised in the poor countries (as noted by FAO, 2008). The biggest concern was how mechanization would affect rural employment options. It was not realized at the time that hired labor was not primarily impacted by mechanization; rather, it was on-farm family employment. In actuality, mechanization

enables farm family members to seek off-farm work options due to the increased time made available to explore for and be engaged in such employment, in addition to increasing farm productivity through production intensification and/or expansion.

Furthermore, it was not realized that mechanization only applied to certain farm production jobs, particularly land preparation, and that it had less of an impact on hired labor unemployment than was previously thought. By pointing out that forced mechanization in the past was linked to the eviction of tenant farmers and rural labor, the International Food Policy Research Institute (IFPRI, 2016a) contributes to the discussion on the social elements related to mechanization. However, mechanization in Africa is more likely to raise labor demand when it allows for the cultivation of additional land (and when it is used in a profitable manner along the value chain). Mechanization is only one part of the process of agricultural intensification, according to IFPRI, and it shouldn't truly start intensification when it isn't already being pushed by market demand and population pressure.

In this regard, IFPRI cites Boserup (1965) and comes to the conclusion that there are numerous locations where the smallholder sector has expressed a desire for automation. Additionally, mechanization boosts value addition in post-harvest activities, primary and secondary processing, as well as services to help with the growth of agricultural mechanization. Given the increasing number of automation alternatives available, it is anticipated that employment in primary agricultural output will decrease; this is due to farming's rising productivity. However, jobs are not truly "lost" because rising agricultural productivity leads to an increase in jobs in secondary agriculture-related occupations, such as the agrifood value chain and services associated to agricultural machinery [4], [5].

Other worries about agricultural mechanization were voiced. Fuel prices were high and steadily rising, and small, dispersed fields were seen as a barrier to tractorization because mechanization would not be practical without land consolidation. Due to all of these factors, the 1980s saw less emphasis placed on mechanization as a crucial contribution. Asia and Latin America, on the other hand, kept up their momentum uninterrupted. In reality, the pathways to agricultural mechanization in Asia, for instance, offer intriguing insights on how SSA can mechanize its agricultural and food sectors in terms of experience, lessons learned, and knowledge exchange. Ghana and Nigeria in West Africa are taking agricultural mechanization lessons from Bangladesh (IFPRI, 2016b). Lessons learned include the creation and use of mechanized technologies (primarily 2-wheel tractors), encouraging and developing the private sector an enabling business environment with public support, research systems connected to stakeholders, and good equipment distribution networks especially in rural areas, developing infrastructure (creating feeder roads into main road networks), and developing the financial system (appropriate financial products development).

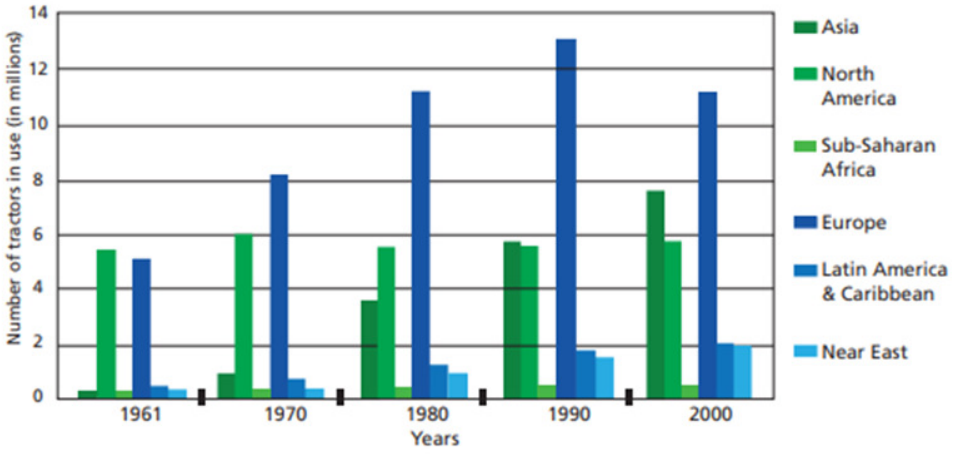
Additionally, according to IFPRI and the Ethiopian Development Research Institute (EDRI) (IFPRI-EDRI, 2016c), Bangladesh's mechanization initiatives are being encouraged and supported across East Africa, more notably in Ethiopia and Kenya. Additionally, there may be valuable lessons to be learned for SSA from the spread of small-scale engine technologies (single cylinder diesel engines) throughout South Asia over the past 50 years. Such engines are in fact employed in a variety of applications, including 2-wheel tractors, shallow tube well pumps, river boats, road and track transport vehicles, harvesters, threshers, grain mills, lumber mills, and processing machinery (IFPRI, 2015c) [6], [7]. According to FAO (2008), who uses

the quantity of 4-wheel tractors as a measure of mechanization progress during the previous 40 years as mention in Figure 2, the following tendencies have emerged:

1. Between 1961 and 1970, the number of tractors in Asia expanded fivefold, from 120 000 to 600 000 units. After that, it multiplied ten times, reaching 6 million units in 2000. Since then, the numbers have increased, particularly in China and India, where there were over 2 million tractors in 2008 (FAO, 2013b) and 2.6 million in 2010 (FAO, 2013a).

2. Between 1961 and 1970, the number of tractors in Latin America and the Caribbean climbed 1.7 times, from 383 000 to 637 000 units, and then quadrupled to reach 1.8 million in 2000.

3. The situation in the Near East is comparable to that in Latin America, as the number of tractors doubled from 126 000 to 260 000 between 1961 and 1970 before rising 6.5 times to reach 1.7 million in 2000. In sub-Saharan Africa, a new pattern has emerged. In 1961, there were more tractors in use (172 000) than there were in Asia and the Near East combined. They gradually grew after that, reaching a peak of 275 000 in 1990 before falling to 221 000 in 2000 [8], [9].



1. Asia includes the People's Republic of China, Japan and India as well as Oceania and Pacific countries.
2. North America includes United States, Canada, Bermuda and Greenland.
3. Sub-Saharan Africa includes all countries on the continent except North African Arab countries (Algeria, Morocco, Tunisia, Libya, Egypt and Sudan).
4. Europe includes ex-USSR up to 1990, thereafter including the Russian Federation and Ukraine and the Baltic States, ex-Asian Soviet Republics are excluded.
5. LAC includes Latin America and the Caribbean.
6. Near East includes all mid-Eastern countries and North African Arab countries.

Figure 2: Tractor Use by Region, 1961-2000.

DISCUSSION

By 2050, the population of the globe, which is currently 7.31 billion people, is expected to surpass 11 billion people. Around 80% of the world's 500 million smallholder farms currently produce food, and it will be primarily up to them to adapt to the requirement to boost food production by over 60% (relative to 2007) by 2050 (FAO, 2011a). Many smallholder farms currently only have limited access to mechanization and other production inputs, which results

in poor levels of productivity and frequently increases the negative environmental effects on already depleting natural resources. Additionally, they have less chances to reach markets and benefit from the various value-adding activities that more advanced food systems can offer.

The rural population is anticipated to decrease at the same time as individuals, particularly the young and fit, move to urban areas in quest of a life with less drudgery than what agriculture has to offer. Smallholder agriculture is also becoming more feminized, particularly in SSA, as women are increasingly left in control of the family farm as the men travel in pursuit of better paying jobs. However, these prospects are sometimes underappreciated. Agricultural mechanization can provide women in rural regions with opportunities that are suitably fitted to cultural, social, and traditional work standards as well as to the general growth of local economies. By 2050, just 30% of the population in developing nations will be estimated to reside in rural areas, down from 50% today (FAO, 2009a). Africa is urbanizing, but its rural population will continue to increase after 2045 at a rate of more than 1% annually [10].

Between 2015 and 2050, there will be an increase of more than 353 million rural residents in Sub-Saharan Africa (AfDB et al., 2016). Despite this population growth, young people and others will continue to move to metropolitan areas in quest of higher paid employment that require less labor than farming. There are significant power limitation ramifications given the existing significant importance of human muscles in smallholder agriculture (Sims and Kienzle, 2015). Human muscles, animals used for pulling a load, and tractor engines are the power sources for agriculture in emerging nations. In different places, different sources are used differently (Table 1). Access to farm power is often not an issue for large farms and the developing agricultural industry in sub-Saharan Africa (farms of 20–50 ha), but it is extremely problematic for smallholder farms (typically 2 ha).

Table 1: Sources of Power for Land Preparation (% of total).

	Human muscle power	Draught animal power	Engine power
Sub-Saharan Africa	65	25	10
East Asia	40	40	20
South Asia	30	30	40
Latin America and the Caribbean	25	25	50

In general, engine power is rising while the number of draught animals is declining, however animals can still be quite significant locally. In Asia and Latin America, the transition from manual labor to tractors and motors for pumping and post-harvest operations has been far more rapid. In India and China, the number of draught animals is drastically declining (from a peak of > 100 million in both countries), and they are being replaced by 4-wheel tractors. In Bangladesh, however, draught animals have been replaced by 2-wheel tractors, which now do 80% of land preparation. The green revolution is credited with starting the transition to profitable commercial farming, reducing rural poverty, preventing the conversion of vast areas of fragile land to extensive farming, and averting potential hunger threats in the face of a growing global population, particularly in Asia. Between 1969 and 2002, the percentage of the world's population that was undernourished decreased from 26 to 14 percent (FAO, 2009b).

There have, however, been grave detrimental effects. The vast increases in agricultural productivity and output were frequently accompanied by negative effects on the rural natural resource base and ecosystem services, compromising agriculture's ability to produce and having an impact on agrifood value chains. Many of the repercussions are seen at the production level, including land degradation due to erosion and compaction, salinization of irrigated regions, excessive groundwater extraction, development of pest resistance, and reduction in biodiversity. Smallholder processing and value addition are much riskier due to the unpredictability and variability of yields, decline in product quality, damaged lands, and reduced water resources.

The green revolution has not had the same impact in Africa as it did in Asia. Over the majority of the continent, low levels of mechanization and intensification, the use of fertilizer, and the adoption of other contemporary technology have all persisted. The continual use of the plough or hand hoe, which causes soil degradation, plough- or hoe-pans in the soil profile, and loss of fertile top soil, are only a few of the many factors that contribute to degraded lands being prevalent across the continent. Given the current low degree of mechanization, substantial soil erosion occurs in many African locations. Long-term agricultural intensification and mechanization in Africa must be done with caution and in accordance with the sustainable production intensification principles outlined by the FAO in its "Save and Grow" guidelines. In order to achieve resilience in the face of a changing climate, Save and Grow is built on environmentally friendly conservation agriculture (CA) mechanization (FAO, 2011a, 2016a).

Farming systems for sustainable production intensification provide producers, other players in the food value chain, and society at large with a variety of productivity, socioeconomic, and environmental advantages. Implementing Save and Grow enables: improved and stable environmentally friendly food production, distribution, and profitability; efficient use and conservation of natural resources; adaptation and reduced vulnerability to climate change; improved ecosystem functioning and services; and reductions in agricultural greenhouse gas (GHG) emissions and agriculture's "carbon footprint". In conclusion, agricultural mechanization in the twenty-first century should be simultaneously: climate-smart, economically feasible, inexpensive, locally adapted, and environmentally compatible. This is especially important in light of recent changes in weather patterns.

These suggested farming and food systems are founded on the following four technical ideas:

1. Achieving higher agricultural productivity while boosting ecosystem services and natural capital.
2. Greater efficiencies in the use of essential inputs, including as labor, energy (including farm power), water, nutrients, and pesticides.
3. The use of controlled and uncontrolled biodiversity to increase a system's resistance to biotic, abiotic, and economic pressures.
4. A food system that is more effective, efficient, and environmentally friendly thanks to greater agricultural mechanization.
5. Depending on local conditions and requirements, the farming techniques necessary to implement the first three principles vary, but they all rest on the following ideas:

i. Minimized mechanical tillage to reduce soil disturbance and preserve soil organic matter, soil structure, and general soil health.
ii. Using crops, cover crops, or agricultural residues to improve and maintain a protective organic layer on the soil's surface in order to protect it, conserve water and nutrients, encourage soil biological activity, and aid in integrated weed and pest control.
iii. Growing a broader variety of species, including annuals and perennials, in associations, sequences, and rotations with grasslands, trees, shrubs, and crops to improve system resilience and crop nutrition.

In actuality, this entails the extensive use of conservation agriculture techniques (FAO, 2015a). This essay focuses primarily on agricultural mechanization and the opportunity it offers for value addition, the growth of the agrifood value chain, and sustainable intensification production, in addition to the inherent chances for better local economies and livelihoods (FAO, 2007). As a result of growing agricultural mechanization in rural regions, the formation of sustainable economic businesses, such as agriprocessors and transport services, is essential for generating job and income opportunities and increasing the market for farm products. The development of commercial agrifood systems and the improvement of post-harvest handling, processing, and marketing operations depend heavily on mechanization. As a result, it controls the availability and accessibility of food as well as the prices paid by urban and rural poor for food, so enhancing household food security. According to IFPRI (2016a), improved access to agricultural mechanization can aid in the development of Africa's agricultural and economic sectors.

CONCLUSION

In order to address issues in the agriculture industry and enhance farming methods, agricultural mechanization is necessary. Utilizing machinery and equipment can increase output, effectiveness, and sustainability. Agricultural mechanization enables farmers to do chores more quickly and efficiently, resulting in larger yields, better crop quality, and greater profitability. Additionally, mechanization helps with the application of precision farming methods, which optimize resource use and reduce environmental effect. The necessity for farmer training and hefty starting costs are just two of the difficulties that must be solved. The backdrop of agricultural mechanization, seen as a whole, underlines the significance of utilizing technology to get around agricultural challenges and implement productive, sustainable farming methods.

REFERENCES

[1] T. Daum and R. Birner, "Agricultural mechanization in Africa: Myths, realities and an emerging research agenda," Global Food Security. 2020. doi: 10.1016/j.gfs.2020.100393.

[2] R. Devkota et al., "Responsible agricultural mechanization innovation for the sustainable development of Nepal's hillside farming system," Sustain., 2020, doi: 10.3390/SU12010374.

[3] H. Takeshima, P. L. Hatzenbuehler, and H. O. Edeh, "Effects of agricultural mechanization on economies of scope in crop production in Nigeria," Agric. Syst., 2020, doi: 10.1016/j.agsy.2019.102691.

[4] T. Daum and R. Birner, "The neglected governance challenges of agricultural mechanisation in Africa – insights from Ghana," Food Secur., 2017, doi: 10.1007/s12571-017-0716-9.

[5] M. Emami, M. Almassi, H. Bakhoda, and I. kalantari, "Agricultural mechanization, a key to food security in developing countries: Strategy formulating for Iran," Agric. Food Secur., 2018, doi: 10.1186/s40066-018-0176-2.

[6] W. Li, X. Wei, R. Zhu, and K. Guo, "Study on factors affecting the agricultural mechanization level in China based on structural equation modeling," Sustain., 2019, doi: 10.3390/su11010051.

[7] D. Albiero, R. S. Xavier, A. P. Garcia, A. R. Marques, and R. L. Rodrigues, "The technological level of agricultural mechanization in the State of Ceará, Brazil," Eng. Agric., 2019, doi: 10.1590/1809-4430-Eng.Agric.v39n1p133-138/2019.

[8] M. M. Kansanga, R. Antabe, Y. Sano, S. Mason-Renton, and I. Luginaah, "A feminist political ecology of agricultural mechanization and evolving gendered on-farm labor dynamics in northern Ghana," Gend. Technol. Dev., 2019, doi: 10.1080/09718524.2019.1687799.

[9] Y. Minli, L. Minzan, and L. Xiwen, "50 Years of agricultural mechanization in China," AMA, Agric. Mech. Asia, Africa Lat. Am., 2020.

[10] M. Jiang, X. Hu, J. Chunga, Z. Lin, and R. Fei, "Does the popularization of agricultural mechanization improve energy-environment performance in China's agricultural sector?," J. Clean. Prod., 2020, doi: 10.1016/j.jclepro.2020.124210.

CHAPTER 10

CHALLENGES FACED BY AGRICULTURAL MECHANIZATION IN SUB-SAHARAN AFRICA

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

In Sub-Saharan Africa, the widespread adoption and efficiency of agricultural mechanization are hindered by several obstacles, including a lack of technical know-how, inadequate infrastructure, excessive costs, restricted financial resources, and limited access to suitable machinery and equipment. Small-scale farmers face challenges in investing in mechanized equipment due to high costs and limited credit and financial services. Poor infrastructure, such as unkempt roads and limited electricity supply, also hinders the efficient operation of machinery in rural areas. Inadequate maintenance and repair services further hampered the sustainability of mechanized equipment. Technical expertise among farmers and service providers is another significant issue, preventing them from fully utilizing and profiting from agricultural mechanization. Additionally, the fragmented nature of land holdings makes it difficult to deploy automation effectively in many Sub-Saharan African nations. To overcome these problems, a diverse solution must be implemented, including enhancing accessibility to affordable mechanized technology, developing reliable infrastructure, offering financial assistance and incentives, and investing in programs to build capacity among farmers and service providers. Collaboration between governments, private sector organizations, and development organizations is crucial for overcoming these obstacles and promoting the effective adoption of agricultural mechanization in Sub-Saharan Africa.

KEYWORDS:

Infrastructure Constraints, Labor Shortage, Rural Technology, Smallholder Farmers, Technology Transfer.

INTRODUCTION

In sub-Saharan Africa, a number of limitations hinder agricultural mechanization and, in fact, mechanization throughout the food system. These obstacles must be recognized in a particular area (or nation), and plans must be made to overcome them so that mechanized services can be developed for the benefit of all farmers, particularly smallholder growers and other participants in the agrifood value chains. The "Enabling the Business of Agriculture" programme of the World Bank is dedicated to identifying and tracking the policies that have a detrimental impact on the agricultural and agribusiness sectors. According to the World Bank (2016), equipment is regarded as a crucial input and market enabler. Below are some of the probable difficulties.

Affordability

Smallholder farmers frequently struggle to invest in physical assets in general and agricultural machinery in particular since they are, virtually by definition, resource poor. Because of the perceived low demand for equipment in rural areas, several nations only have agricultural machinery vendors in their major towns and cities. This is because the construction of

distribution networks is not always justified. Smallholders are frequently cut off due to distance and inadequate infrastructure, particularly feeder roads. Lack of targeted financial products for investing in farm equipment, widespread misconceptions about the need for such products, the inherent riskiness of agricultural production, and the unwillingness of commercial financial institutions primarily banks to extend credit to low-income farmers with little collateral all contribute to the limited availability of sources of financial credit. Extending credit products to farmers so they can invest in agricultural machinery not only enables them to increase their productivity and engage more fully in the market economy, but it can also encourage the local machinery manufacturing industry to meet their needs. This is proven by experience from other parts of the world. Smallholder farmers' limited purchasing power is influenced by a number of economic issues that affect farm families, including: Low yields basic grain crops of less than 1 tonne/ha are a result of a number of factors, such as a lack of sufficient inputs especially seed and fertilizer at the right price and timing, climate change with longer drought periods and more frequent storms, and the deteriorated state of many agricultural soils [1], [2].

1. Market pricing are low.
2. Expensive transportation.

Problems with farmgate prices could be a significant deterrent for smallholder farmers. Farmers are hampered by a lack of free competition in these markets, which has resulted to high prices for agricultural inputs and lower farmgate prices for produce compared to other regions of the world. Private sector-driven input and output markets have not grown as swiftly as anticipated. The level of investment in agriculture has generally decreased as a result of the loss in farm revenues and the absence of incentives to market produce. Low investments in fixed assets, such as agricultural machinery, which frequently have significant start-up costs and returns spanning a long period of time, and which may be economically unsustainable for smallholders (even if profitable), are indicative of this. Ghana and Nigeria also had this tendency noted (IFPRI, 2012, 2014a, 2014b).

Additionally, farmer groups have had varying degrees of success in increasing smallholders' access to markets and public services, as well as in providing their members with machinery services. Although farmer organizations are aware of the social and economic advantages that automated services might provide for farmers, they are not always equipped to manage these services. However, some community-based farmer groups such as cooperatives are effective in providing their members with mechanization services. For instance, indicate that cooperatives providing successful mechanization services to members in Benin are set up at the field level a bottom-up strategy and offer their members significant financial returns, which has a favorable effect on the members' social standing. Additionally, the cooperatives have beneficial connections with local banks and other important parties.

With a system set up locally, based on the active involvement of small-scale farmers and the idea of self-help, cooperatives offering mechanization services in Nigeria can provide their members with both economic and social benefits. One of the most crucial challenges in agriculture is land tenure; in many nations, a lack of tenure security severely deters investment in the agricultural sector. Land tenure must be safe and secured by the state as well as by local laws and traditions for a successful transition from semi-subsistence farming to profitable, productive agriculture. Farmers now have the protection and assurance they need to spend money on automation and other production-enhancing inputs. There are rules to control land tenure in various nations, although they are not always successful. For instance, where common land ownership by clans and extended families is the norm, commercializing farming and altering such patterns of land ownership are extremely difficult. Despite the implementation of

national legislation, no "secure" land transaction can occur in many nations without the involvement of the traditional chiefs; an investor is required to offer "gifts" not only when farming begins but also when a change of title occurs. As the world population rises and climate change makes agricultural production uncertain, other problems like "land-grabbing" are becoming more prevalent and significant.

Additionally, in addition to those connected to land tenure, disputes over water tenure, diminishing ground and river water supplies, and increasingly variable rainfall (FAO, 2016b) create an unfavorable climate for expanded farm commercialization. Smallholders living above the subsistence level are frequently quite risk-averse. For a rural family, a consistent source of food is preferable than one whose yields may be very high in favorable seasons but very low in unfavorable years, even if they are much below the level of possible yields for the location. It is ideal to have a consistent yield, even if it is modest, that is resistant to the whims of the weather, but this does not guarantee a surplus that can be sold. Due to these factors, smallholders are unlikely to be able to invest in the kinds of mechanization technologies that could help them escape their difficult situation without financial support [3], [4].

Availability

Both locally and internationally manufactured tractors and agricultural equipment may have potential issues. Machinery made locally is typically expensive and of poor quality. This is a result of the underdeveloped state of the machinery manufacturing sector, which is mostly attributable to a lack of market demand. Additionally, supply networks that offer spare parts, guidance, and other services particularly clean fuel to owners of tractors and agricultural gear are frequently underdeveloped and difficult to access (FAO, 2009d). Analysis of the low adoption of mechanization and the connections between the various drivers demonstrates unequivocally that SSA conditions have produced a constrictive environment that has slowed the growth of mechanization. Figure 1 demonstrates how low farmer income (1), has a very low potential impact on input investment (2). There is little demand for tools and machinery because inputs include agricultural machinery in addition to seed and fertilizer (3). Very low levels of productivity are the outcome of this lack of investment in production-enhancing technologies (4), which further solidifies the ongoing issue of poor farmer income.

Another crippling factor is supply, which is driven by a lack of demand for mechanization (see bottom part of Figure 1). Lack of tools, equipment, and power sources (limited selection and low sales volume) (5) often results in higher agricultural mechanization costs (6), which then result in higher ownership and operating expenses (7). The vicious circle that results in low demand is completed by the high cost of using farm equipment. These connected elements highlight the structural barriers that prevent more African nations from adopting automated farming practices. They emphasize the interdependence of input demand and supply for agricultural mechanization. On the other side, they also show how limiting elements can be changed into empowering ones [5], [6].

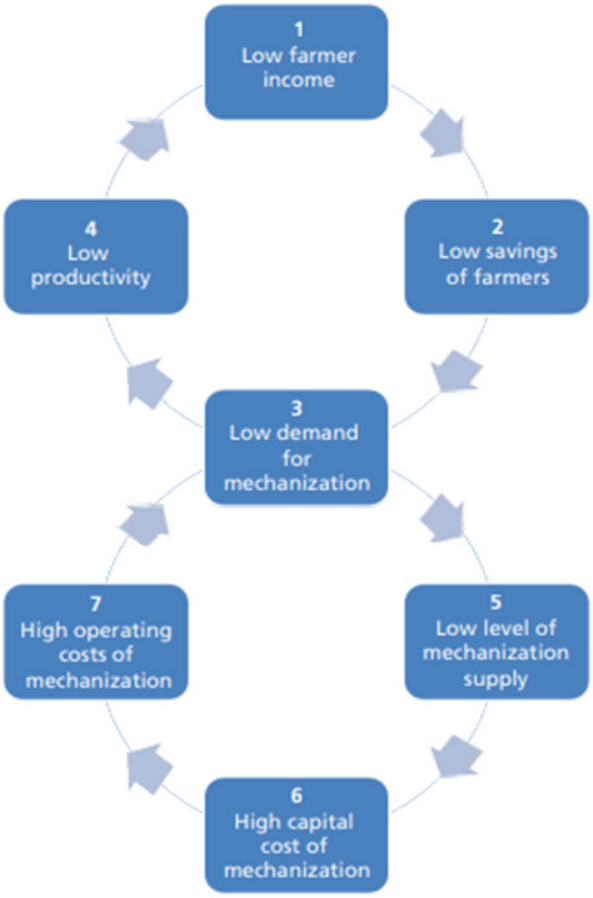


Figure 1: Factors weakening the demand and supply of agricultural mechanization.

DISCUSSION

Lack of Farmer Skills

Despite having a wealth of accumulated traditional knowledge and experience, African farmers have comparatively little access to new knowledge. There are few options for additional training and the level of farmer training is relatively poor. Rural and distant places are difficult to access for public and commercial extension and training services due to long distances and sometimes limited transportation. It could be challenging to economically justify such operations if there is little demand for training and extension. Rural farming populations have a high illiteracy rate, which makes it difficult to increase agricultural productivity and production as well as farm management in general. For instance, only land preparation and transportation are performed using tractors in many SSA nations (FAO, 2009c), whereas other tasks like planting and harvesting are primarily completed by hand. Farmers lack the knowledge and expertise necessary to operate mechanized equipment (FAO, 2011c), and when machines are employed, this lack of competence results in misuse and improper management of technology, particularly more advanced machinery [7].

Constraints within the Private Sector

There are limitations that prevent the growth of the entire agricultural machinery subsector, which includes manufacturers, importers, distributors, merchants, and business entities that provide hire services. Other developing private sector subsectors face many of the same

challenges, including: a lack of enabling legislation to ease business startup and enterprise operations; complicated fiscal systems; punishing import rules; and strict labor laws. In many SSA nations, the private sector's production of agricultural machinery is still in its infancy; it is constrained by imports and global competition, and it is held back by poorly established distribution networks. Mechanization hiring service markets are also in their infancy; typically, there is very little demand since smallholders are not aware of the necessity for mechanized services. Lack of development is the main cause of low demand, however there are additional limitations [8].

Agricultural Machinery Importation and Distribution

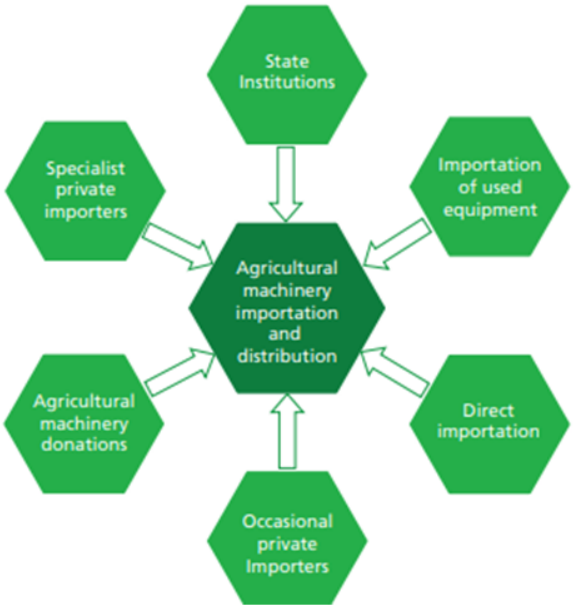


Figure 2: Agricultural Machinery Importation and Distribution.

A variety of channels are used to import and distribute farm equipment (Figure 2). Some have greater long-term viability and success than others:

A small number of carefully chosen brands are often imported and sold through franchisees that specialize in private imports of farm machinery. The franchise is bought by the importer from the producer. These businesses may have branches in other significant cities and towns, but their headquarters are normally in the nation's capital city. Traditionally, they have been franchisees of significant Western farm machinery producers, although Asian and Latin American producers have recently entered the market. However, sales of large pieces of equipment (such as tractors and combine harvesters) continue to be extremely low in nearly all SSA markets. Franchise businesses frequently sell different types and brands of equipment as a result of this. Rare private importers are typically general merchants without a specialty in or familiarity with farm machinery. These businesses typically import a number of machines, and after they are sold, they are free to stop offering servicing or spare parts. It's possible that a later batch of machines will be produced by a different company.

Farmers that make purchases from these businesses typically lack experience and are ignorant of potential future issues with repair services and spare parts.In some nations, state institutions and humanitarian organizations are involved with the importation of farm equipment. Additionally, a number of African nations have established regional tractor assembly facilities in an ineffective effort to advance agricultural mechanization or in an effort to provide lower-

cost machinery. Governments and aid organizations may also import farm equipment in bulk when they publish tenders for the acquisition of significant quantities of the equipment. Similar to private imports, the machinery typically avoids the regional distributor, who is not obligated to offer replacement parts or services. Whether a bidder has a local agent or the ability to offer post-sales services is typically not taken into account when evaluating tenders; just the price is considered. As a result, machines frequently become "orphans" without spare parts or backup services. They may start out being inexpensive, but they often have a very short functioning life. As a result, they become highly expensive. Donations of agricultural equipment and other tools are frequently made to nations in Africa. Unfortunately, almost all of these well-intentioned programs fall short of their intended outcomes. Spare parts are not readily available since donor country items are incompatible with other machines that are currently on the market [9].

Donated equipment soon turns into "orphans" because no services are accessible and, once the first failures happen, there is no way to fix the equipment. There are "graveyards" for machinery in several nations. Only large-scale farmers and agri-industrial firms can choose to import directly. They can decide to import machinery straight from abroad if there are significant reductions offered for large purchases. The business or farm must have enough resources to maintain an inventory of spare parts and perform maintenance and repairs. When specialist equipment, such as sugar-cane harvesters, is required, direct importation is another option.

In order to meet demand in some nations, used machinery imports, in particular those of tractors, combine harvesters, and other specialist machinery, may offer farmers an alternate source of cheaper equipment. In actuality, though, farmers may not benefit from this approach because the importer does not usually offer extra services like repairs and the provision of replacement parts. Used machinery is frequently imported and sold in nations with a supply of specialists with a high degree of training and expertise but low labor costs. The temptation to participate in the importation of machinery, whether new or used, may exist in the public sector. Failure is, however, all but certain without expert knowledge of agricultural equipment.

Manufacturing of Farm Tools and Machinery

SSA nations' industrial sectors create a vast variety of hand tools, farming tools, and processing equipment. Facilities differ between nations; in some, only the most basic hand tools are produced, primarily in the artisan (blacksmith) sector, while in others, advanced manufacturing facilities are present. Farm tool and machinery manufacturing has also benefited from bilateral and multilateral cooperation over the years, but the sector is not always sustainable due to erratic raw material supplies, fluctuating demand, quality concerns, as well as challenges that arise when projects place large orders all issues that are typical of private sector development. Currently, there are three major types of manufacturers: informal artisan activities, privately owned and operated businesses, and state-owned and operated corporations.

Maintenance and Repair Services

The upkeep and repair of hand tools and equipment used for animal traction are often simple tasks completed locally by tiny workshops in the informal sector. However, training and refresher courses are not always offered, a problem shared by other private sector micro-enterprises. Following standardization, the availability of replacement parts has increased in several nations, facilitating the interchangeability of tools purchased from various manufacturers. Tractors in particular are an example of motorized farm machinery and equipment when this is not the case. Poor maintenance facilities and a frequent critical shortage

of spare parts cause prolonged equipment downtime, underuse, and ultimately premature write-offs. A few decades ago, there was a lot of focus on public sector initiatives and projects to provide maintenance and repair facilities for agricultural machinery. These, however, were not particularly successful, and the majority have since been abandoned [10].

Hire Services

Although there are numerous countries that offer mechanization hiring services, there are a number of obstacles: limited market access, low demand, lack of funding, and a lack of business management and profit-maximizing expertise. For instance, various market and social flaws make it difficult for hire services to be effectively commercialized in Nigeria (IFPRI, 2015b). Tractors are expensive, loans are difficult to obtain because to high transaction costs, and equipment sharing is essentially nonexistent. A wide range of operations can be covered by machinery hire services, including: crop operations such as soil tillage, planting, and spraying post-harvest services such as threshing, shelling, and processing transport services; and collection of biowaste and other refuse in rural, peri-urban, and urban areas. The fact that hire services are offered when animal draught is the source of power should not be overlooked. They are not just available for motorized activities.

In an effort to incorporate small farmers in expanding markets for high-value commodities throughout the 1960s, numerous nations launched public-sector-run farm machinery hire businesses. The majority of these plans, which mainly aimed to provide tractor hire services, did not yield the desired results or benefits. Although some government subsidies may still be available, for the most part, SSA has seen the demise of such programs due to a variety of factors, including: small fields with extensive travel distances; expensive hire fees; untimely payments; rigid and ineffective public sector administration; a lack of incentives for operators and mechanics; breakdowns; and the non-sustainability of subsidies needed to maintain the service. Therefore, unless supplemented with an entrepreneurial spirit and private sector partnerships, public sector tractor hire services are unsustainable. For instance, the agricultural mechanization service centers that the government pushed in Ghana (IFPRI, 2013) were not designed with farmers in mind, and the government's direct procurement of agricultural machinery discouraged private imports of suitable and economical machinery. A viable model for sustainable mechanization, in contrast, is the growth of a market for hiring mechanized services, in which medium- and large-scale tractor-owning farmers offer hire services to small-scale farmers (IFPRI, 2015d).

The private sector does offer hiring services in several nations, but on a very modest scale; in fact, the normal scenario is that tractor owners have extra capacity and rent out their vehicles to make money to help with expenditures. Customers are typically familiar, close-by farmers who give the business owner the assurance that they will be paid sometimes in kind for the services rendered. Local entrepreneurs who invest in two or three equipment and operate small-scale contractor (hire) enterprises are becoming more and more common. These firms are often located in areas where the contractor is familiar with his or her clientele. Private sector tractor rental businesses should vary their offerings to increase profitability and provide them the option to promote their services all year round.

Gender Issues in Smallholder Mechanization

In sub-Saharan Africa, women typically provide 60 to 80 percent of the labor for food production and have a wealth of traditional knowledge regarding how to deal with the environment and natural resources. According to a study done in Kenya and Ethiopia, the majority of the labor-intensive tasks for women are weeding, tillage, and land preparation;

managing and transporting agricultural produce after harvest; gathering and chopping fodder; and providing for children. Because it is assumed that women are supposed to work hard, the writers discovered few indications of mechanization to ease the strain. Women themselves lack the time to acquire resources and information that could help lower the job burden through investments in mechanization, and advocating for a reduced work burden for women does not conform to social standards. In fact, males are frequently the ones who conduct business at the farm level, and as a result, they are the ones who decide to engage in automation and have control over the necessary resources particularly capital. Women play a more and bigger part in agricultural production and commercialization as a result of the continued trend of male migration to urban regions and the advancement of climate change, but they still have limited access to mechanization.

CONCLUSION

In conclusion, Sub-Saharan Africa has formidable obstacles that prevent widespread adoption and efficiency of agricultural mechanization. These difficulties include a lack of technical know-how, poor infrastructure, excessive costs, limited financial resources, and limited access to appropriate machinery. A comprehensive strategy is needed to address these issues, one that includes expanding access to appropriate and affordable technologies, funding the development of infrastructure, offering financial assistance and incentives, and improving technical expertise among farmers and service providers. To overcome these obstacles and encourage the successful adoption of agricultural mechanization in Sub-Saharan Africa, cooperation amongst many stakeholders is important.

REFERENCES

[1] V. Balasubramanian, M. Sie, R. J. Hijmans, and K. Otsuka, “Increasing Rice Production in Sub[hyphen (true graphic)]Saharan Africa: Challenges and Opportunities,” in Advances in Agronomy, 2007.

[2] V. Balasubramanian, M. Sie, R. J. Hijmans, and K. Otsuka, “Increasing Rice Production in Sub-Saharan Africa: Challenges and Opportunities,” Advances in Agronomy. 2007. doi: 10.1016/S0065-2113(06)94002-4.

[3] P. B. Cobbinah and G. K. Anane, “Climate change adaptation in rural Ghana: indigenous perceptions and strategies,” Clim. Dev., 2016, doi: 10.1080/17565529.2015.1034228.

[4] A. R. Böttner, “Mecanización agrícola y fomento estatal en Chile (1942-1973),” America Latina en la Historia Economica. 2016. doi: 10.18232/alhe.v23i3.720.

[5] B. Pan and Z. Tian, “Mechanism of factor substitution during rapid development of China’s agricultural mechanization,” Nongye Gongcheng Xuebao/Transactions Chinese Soc. Agric. Eng., 2018, doi: 10.11975/j.issn.1002-6819.2018.09.001.

[6] M. S. Turmel, A. Speratti, F. Baudron, N. Verhulst, and B. Govaerts, “Crop residue management and soil health: A systems analysis,” Agric. Syst., 2015, doi: 10.1016/j.agsy.2014.05.009.

[7] T. G. I. Mansour, M. Abo El Azayem, N. El Agroudy, and S. S. Abd El-Ghani, “Production and marketing problems facing olive farmers in North Sinai Governorate, Egypt,” Bull. Natl. Res. Cent., 2019, doi: 10.1186/s42269-019-0112-z.

[8] B. Deepa, K. S. Jeen Marseline, and S. Nandhini, "Convergence of wireless sensor network and data mining for pest mangement in agriculture," Int. J. Recent Technol. Eng., 2019.

[9] C. N. Sakhale and A. Prof, "A Review Paper on' Multipurpose Farm Machine' Prof. S.N.Waghmare Literature Review," Int. Res. J. Eng. Technol., 2016.

[10] C. O. Ojo, Y. M. Bulama, and U. A. Mohammed, "Gender Analysis of Determinants of Labor Input among Yam Farmers in Paiko Local Government Area of Niger State, Nigeria," Greener J. Agric. Sci., 2013, doi: 10.15580/gjas.2013.3.072313747.

CHAPTER 11

OPPORTUNITIES PROVIDED BY AGRICULTURAL MECHANIZATION IN SUB-SAHARAN AFRICA

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

Sub-Saharan Africa has significant potential for agricultural mechanization to modernize the industry, boost output, and improve rural living. This can lead to increased productivity, better crop yields, improved value chain integration, and environmentally friendly farming methods. Mechanization helps farmers complete chores more efficiently, reducing labor-intensive tasks and increasing overall production. This leads to higher crop yields and farm profitability. Additionally, mechanization allows for the integration of the value chain, particularly in post-harvest handling and storage. This leads to lower post-harvest losses and improved agricultural output quality. Precision agriculture technology, such as GPS-guided machinery and sensor-based systems, minimizes environmental impact, reduces input waste, and supports sustainable resource management. Agricultural mechanization also offers opportunities for rural development and job generation, as qualified technicians, operators, and service providers are needed. Governments, development organizations, and private sector stakeholders must implement supportive policies and financial commitments to capitalize on these opportunities. Collaboration among diverse players is crucial for financial support for implementing mechanized technologies, upgrading infrastructure, facilitating training and capacity building, and ensuring access to the right machinery.

KEYWORDS:

Agricultural Productivity, Economic Growth, Farm Efficiency, Farming Technology, Labor Savings, Machinery Innovation.

INTRODUCTION

A variety of options to improve the agricultural sector and spur economic growth are presented by agricultural mechanization in sub-Saharan Africa. Farmers in the area have the opportunity to boost productivity, raise yields, improve food security, and encourage sustainable agricultural practices by implementing mechanized technology and equipment. Value chain integration, employment creation, and rural development are also included in these opportunities. However, to take advantage of these opportunities, governments, development organizations, and the business sector must work together and implement supportive policies and investments. Sub-Saharan Africa can unleash its agricultural potential and pave the road for a more prosperous and sustainable future by taking advantage of the opportunities presented by agricultural mechanization [1].

Raising Farmer's Incomes through Sustainable Crop Production Intensification and Sustainable Commercialization

The most attractive hope, given the existing level of agricultural mechanization in sub-Saharan Africa, is to change the vicious cycles into virtuous cycles (Figure 1).

Figure 1: Virtuous Cycles Resulting from Sustainable Crop Production Intensification.

Figure 1 demonstrates how a stable increase in farm family income (1) can have a good domino effect on the availability of necessary farm mechanization and power. First, higher revenues enable more savings (2), and the need for agricultural mechanization services or the purchase of farm machinery (and other inputs) becomes a prospect that the farmer can afford (3). As a result, productivity increases (4), which further boosts farm revenues. In addition, it can be observed in the bottom circle how a rise in demand for agricultural mechanization (3) results in a parallel improvement in supply as a result of a market reaction (5). A growing market results in lower operational expenses per unit (6) and lower prices without compromising profitability (7).

As a result of higher demand being sparked by lower costs, the virtuous cycle is complete. The UN's first sustainable development goal (SDG) and a top priority worldwide is to eradicate poverty. 80 percent of the world's extremely poor people reside in rural areas and depend primarily on agriculture, according to FAO (2015d). Additionally, agricultural expansion is at least twice as successful as growth in other sectors at reducing hunger and poverty in low-

income and agrarian economies. Investment in rural development, the establishment of social security systems, the strengthening of rural-urban ties, and a focus on raising the incomes of the key change agents, such as smallholder farmers, are all ways to increase farm family incomes [2].

Smallholder farmer productivity must be increased in a sustainable manner, taking into account the knowledge gained from the "green revolution" (GR). The GR caused changes in crop varieties and agricultural techniques all around the world starting in the 1950s and continuing into the 1960s (Royal Society, 2009). The production model was based on homogeneity, promoting genetically uniform varieties grown with high levels of complementary inputs (e.g. irrigation, fertilizers, and pesticides), often replacing more environmentally friendly practices. The initial focus was on the introduction of genetically improved, higher-yielding varieties of wheat, rice, and maize in high potential areas. Herbicides and pesticides replaced crop rotation as a method of managing weeds, pests, and diseases, while fertilizers took the place of organic soil quality management. The GR, however, had grave drawbacks, as mentioned above in Chapter 1. It is now essential to incorporate sustainability into the expected future production growth, especially in SSA. According to the Save and Grow paradigm (FAO, 2011a, 2016a), crop output should be intensified while protecting sensitive natural resources. This is done by using considerably improved land management practices, such as conservation agriculture. Raising smallholder incomes and creating new mechanization opportunities require more than simply a sustainable improvement in production; farm goods also need to be sustainably commercialized. Smallholders could boost their chances of commercialization by implementing machinery for on-farm value addition or more efficient market transportation. Incomes will rise and more opportunities for mechanization will arise as more people have access to more profitable and sustainable forms of commerce [3].

New opportunities for Agricultural Mechanization Development

Despite the difficulties mentioned in above chapter, there are significant prospects for mechanized development in many African countries in the near future. After decades of declining food output per person, there is now a new environment of hope and a changed foreign investment environment. The fast growth of metropolitan areas and the resulting demand for agricultural products, along with the rises in the price of food commodities internationally, all point to the agriculture industry becoming commercially sustainable. For a variety of reasons, the new environment will present chances for the acceptance and growth of agricultural mechanization [4].

DISCUSSION

1. Increasing Agricultural Wages: Young people are migrating from the countryside to the cities as a result of the growth and expansion of off-farm jobs as well as their disillusionment with the grueling agricultural work (hard physical labor and drudgery). As a result, there has been a shortage of physical labor, especially during busy periods, which has raised salaries in rural areas. According to Ratolojanahary (2016), the adoption of agricultural mechanization is influenced by the cost of labor. Farmers have little motivation to invest in machinery if the cost of labor is kept low; mechanization is encouraged by high labor wages. Generalizations for the entire SSA should be avoided because the situation is country-specific. Sometimes migrant workers from

other regions or countries fill labor shortages, which results in a drop in the high rates that were previously paid. The motivation to invest in agricultural mechanization is removed by the increase in labor demand and resulting decrease in wages. However, in some nations, a lack of labor has led to a rise in the demand for hired services to supplement hired labor, particularly during busiest seasons (such as planting and harvesting crops).

2. New Sources of Farm Machinery More suitable for African Conditions: Western technology, which was previously a significant supplier of farm equipment for Africa, has advanced, making it less appropriate for smallholder farming circumstances in Africa and more expensive for African farmers. Tractors and farm equipment, which are increasingly common in local markets, are now available from new growing industrial economies like India, China, and Brazil. This equipment is significantly less expensive than equipment made in Western Europe or North America and frequently better suited to African climates. Particularly inexpensive versions of basic 2- and 4-wheel tractors, which can be directly or jointly owned or bought by businesses that offer mechanization services, are suitable for providing tractive power for smallholder farms. Despite the fact that equipment from China, Brazil, and India is frequently less expensive and low-tech, there is evidence from the field that these products are more likely to fail sooner due to their lower quality. Additionally, when compared to technology from well-known global corporations, the after-sales service quality can differ. Machines made by western manufacturers like AGCO, John Deere, and CNH are often sent to Africa after being made in Brazil (AGCO) or India (John Deere). One example of a product like this is the AGCO starter kit of implements, which is inexpensive (USD 20 000) and based on an MF35 tractor (IFAJ, 2015). It is typically reliable, high-quality equipment that is more affordable and better suited to the SSA market [5].

3. More creative and energy-efficient sustainable mechanization ideas that adhere to the FAO "Save and Grow" philosophy are required: African nations must change to accommodate the global energy problem and emerging energy-saving technologies. Concepts of energy efficiency must be explored further, and alternative energy sources must be used. The continent is the center of attention for the development and usage of solar power due to the potential for its utilization. There are currently several technologies available for pumping water, drying fruits and vegetables, and generating electricity. The FAO's Save and Grow concept, which was covered in Section 3.1, paves the way for sustainable crop production intensification using leaner, more precise, and energy-efficient production techniques, such as reduced and no-tillage or direct-seeding practices. Increased mechanization must be combined with cheaper precision farming tools that are more widely available, making the most of ICT apps to get real-time updates on weather, pest and weed conditions, market prices for inputs and products, and meteorological conditions. The handheld GreenSeeker, which is used to apply pricey fertilizer inputs precisely, is an excellent illustration of a precision farming instrument (Trimble, 2016).

4. Climate-Smart and Conservation Agriculture- the need for environmentally sustainable mechanization: There is no denying the effects of climate change, and more instances of severe storms, warmer temperatures, and more drought are likely (IPCC, 2014). These harmful events won't just keep happening; they'll get worse thanks to the continued emissions of greenhouse gases (GHGs). Therefore, agricultural innovation is essential to maintaining crop production, and if productivity is to be increased, the inventions must be extremely strong indeed. World leaders and significant international donors have called for new agricultural ideas that are more climate-smart (FAO et al., 2014). The use of agricultural machinery for soil tillage, which consumes fuel and causes environmental damage, has occasionally drawn criticism for its potential harmful effects. The key to climate-smart agriculture is the creation of new tools and precise methods that are more environmentally friendly. Agriculture conservation (CA) is a potent idea. In California, direct seeding is used through the vegetative cover to keep a permanent cover on the soil. The delicate soil is never directly exposed to the sun's rays, strong winds, or heavy precipitation. Only because specialized equipment has been developed is direct sowing feasible. It is anticipated that other innovations or technology will be used to address new environmental issues. Building resilience against the extreme weather events that are predicted to become more frequent as a result of climate change requires the use of climate-smart agriculture.

5. New Need for Sustainable business models for mechanization in Africa: Generally speaking, there is a latent need for mechanization services in SSA; yet, many potential clients, primarily smallholders, are unaware of this desire. Customers must be made aware of the services offered if agricultural mechanization is to progress and the agricultural and industrial industries as a whole are to grow. Identifying business concepts that are suitable for regional conditions in the various SAA countries is also crucial. Different business models may be appropriate for launching a machinery service business and for helping it develop and thrive in different nations, within those nations, and over time. SSA regions may appear underdeveloped in terms of economic activity, but there is great potential for the creation and acceptance of novel concepts for business models that are tailored to the local circumstances. This potential shouldn't be disregarded because it offers a significant opportunity for creative businesses (FAO, 2012) [6], [7].

Investing in Agricultural Mechanization for Sub-Saharan Africa

In order to discuss the prospects and requirements for investment in agricultural mechanization in SSA, FAO and UNIDO (United Nations Industrial Development Organization) teamed up in 2009 (FAO, 2011c). The suggestions that were made centered on making it easier to promote private and public sector investment flows into the expansion of agricultural mechanization in Africa. The principal goals were reducing the amount of primary land preparation done by hand tools from 80% to 40% by 2030 and subsequently to 20% by 2050, and replacing them with a combination of tractors and draught animal power. The following were the main suggestions:

1. Establish national committees on agricultural mechanization: Farmers' organizations, financial institutions, manufacturers, dealers, and research and development (R&D) institutions are just a few of the major stakeholders represented by national committees

on agricultural mechanization (NCAMs), which can assist governments in reviewing national policy on mechanization, determining the need for a national mechanization strategy, and ensuring the compatibility of machinery.

2. Create an enabling environment: The promotion and support of local, entrepreneurial machinery contracting businesses; the rationalization of rules for the use of tractors in off-farm applications (especially rural road infrastructure contracting); and, where possible, the expansion of irrigation areas are all examples of policies, institutions, and regulations that can help to promote and facilitate the increased use of tractors and related agricultural machinery.

3. Increase Investment in Agricultural Mechanization: Encouragement of the financial sector, including banks and other lending organizations, is essential if farmers and other investors in tractors and agricultural equipment are to receive credit lines.

4. Capacity Building: It is necessary to conduct a thorough examination of the situation as it stands and of the steps that must be taken to guarantee that there are sufficient training facilities to support safe and environmentally friendly automation. The demands of farmers, operators, mechanics, and other pertinent stakeholders involved in the supply of agricultural machinery services should be taken into consideration while developing training programs (Figure 2). In order to integrate the many knowledge building blocks needed in the mechanization and agrifood value chains and ultimately produce highly competent mechanization business managers, training centers should be connected to the existing further education institutions [8], [9].

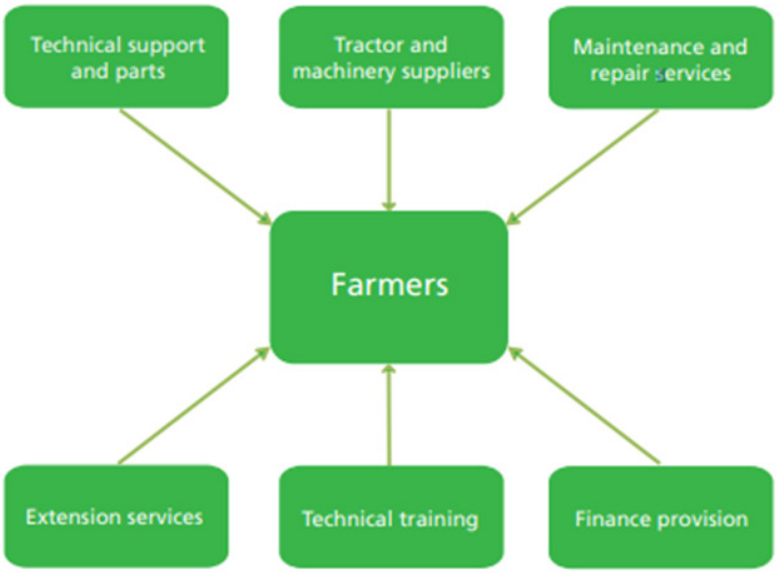


Figure 2: Stakeholders in the farm machinery support network for smallholder farmer.

5. Establish a code of practice for agricultural machinery suppliers: A fundamental necessity for advancing agricultural mechanization is the availability of high-quality, secure agricultural equipment. High-quality, dependable, and economically priced equipment is required. Technical support and post-sale assistance are crucial for the

provision of components, maintenance, and repairs. To provide good service to end users, industry institutions and stakeholders may agree on a code of conduct, which may be developed with the support of organizations like FAO and UNIDO.

6. Create regional networks of agricultural mechanization: Regional networks should promote participation in professional associations, farmers' organizations, R&D organizations, manufacturers, and distributors. It is crucial to establish connections with current networks for CA, draught animal power, and mechanization. The FAO and UNIDO are happy to contribute their appropriate expertise. The discussions of this high-level international panel of experts emphasize the significance of expanding mechanization services to smallholder farms, even though some ideas will be more pertinent than others depending on the circumstances in each SSA country [10].

CONCLUSION

In conclusion, the mechanization of agriculture in sub-Saharan Africa presents enormous prospects for the development and transformation of the agricultural industry. Farmers can boost productivity, yields, food security, and sustainable farming practices by implementing mechanized technologies. Additional advantages of adopting agricultural mechanization include value chain integration, employment generation, and rural development. It is crucial to have supportive policies, investments, and stakeholder engagements in order to take advantage of these prospects. Sub-Saharan Africa can unleash its agricultural potential and promote a more prosperous and sustainable future by taking advantage of the opportunities offered by agricultural mechanization.

REFERENCES

[1] A. Hayati, A. Marzban, and M. Rahnama, “Strategic analysis of ergonomic and safety problems in mechanization of date palm crown access operation with the sustainable agricultural development approach,” Iran Occup. Heal., 2020.

[2] B. Zhang et al., “A company-dominated pattern of land consolidation to solve land fragmentation problem and its effectiveness evaluation: A case study in a hilly region of Guangxi Autonomous Region, Southwest China,” Land use policy, 2019, doi: 10.1016/j.landusepol.2019.104115.

[3] R. Hanlin and R. Kaplinsky, “South-south trade in capital goods - The market-driven diffusion of appropriate technology,” Eur. J. Dev. Res., 2016, doi: 10.1057/ejdr.2016.18.

[4] K. Descheemaeker et al., “Exploring transformative pathways towards sustainable farming systems in the cotton zone of West Africa,” Int. Conf. Glob. Food Secur., 2020.

[5] M. H. Ollenburger, K. Descheemaeker, T. A. Crane, O. M. Sanogo, and K. E. Giller, “Waking the Sleeping Giant: Agricultural intensification, extensification or stagnation in Mali’s Guinea Savannah,” Agric. Syst., 2016, doi: 10.1016/j.agsy.2016.07.003.

[6] Q. Zhang, “Machine Area Networks,” in Encyclopedia of Agricultural, Food, and Biological Engineering, Second Edition, 2010. doi: 10.1081/e-eafe2-120043055.

[7] C. Bolten, “The agricultural impasse: creating ‘normal’ post-war development in Northern Sierra Leone,” J. Polit. Ecol., 2009, doi: 10.2458/v16i1.21692.

[8] C. R. Doss, “Women and agricultural productivity: Reframing the Issues,” Dev. Policy Rev., 2018, doi: 10.1111/dpr.12243.

[9] M. Kumar et al., “Microplastics as pollutants in agricultural soils,” Environmental Pollution. 2020. doi: 10.1016/j.envpol.2020.114980.

[10] B. T. Anang and B. O. Asante, “Farm household access to agricultural services in northern Ghana,” Heliyon, 2020, doi: 10.1016/j.heliyon.2020.e05517.

CHAPTER 12

AN OVERVIEW OF THE WAY FORWARD SUGGESTED ACTION

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

To encourage agricultural mechanization in sub-Saharan Africa, governments should implement policies such as tax breaks and subsidies for machinery and equipment purchases. Addressing land tenure, financial availability, and infrastructure development should also be addressed. Increasing research and development spending can create affordable mechanization technologies tailored to the region's unique needs. Enhancing the effectiveness of extension services and providing training courses can improve the use of mechanized equipment. Providing access to financing through low-interest loans, leasing options, or cooperative financing models can help small-scale farmers invest in mechanization. Fostering information exchange and capacity building can help farmers understand the advantages and efficient application of mechanized technologies. Strengthening rural infrastructure, including road networks, irrigation systems, and power supply, is essential for promoting mechanization adoption. Fostering public-private partnerships between governments, businesses, and development organizations can accelerate the adoption of mechanization by leveraging available resources, knowledge, and market connections. By implementing these recommendations, sub-Saharan Africa can remove obstacles to agricultural mechanization and promote enhanced production, better livelihoods, and sustainable agricultural practices.

KEYWORDS:

Implementation, Solutions, Recommendations, Progress, Roadmap.

INTRODUCTION

The agricultural mechanization scenario in developing nations has been extensively analyzed in several instances throughout the years (FAO, 2008, 2011c, 2014b; FAO and UNIDO, 2008). Five motifs keep coming up:

1. If agricultural productivity and production are to rise and manage to feed the world's expanding population, farm electricity and mechanization are crucial inputs.
2. Crop production must be intensified in a sustainable manner, with an environmental impact that is as small as feasible and, in any event, slower than the pace of natural regeneration.
3. Top-down approaches are rarely effective; all stakeholders must be taken into account from the beginning, and the private sector must take the lead in actual development.
4. The public sector's job is to create an atmosphere that allows the private sector to operate effectively without unneeded barriers.
5. Agricultural mechanization requires a holistic, value-chain approach that goes beyond green production and includes post-harvest, processing, and marketing operations [1], [2].

Briefly stated (FAO and UNIDO, 2008):

There is an urgent need for everyone involved, including farmers, supporters, planners, and policymakers, to comprehend and contribute to agricultural mechanization efforts across the entire farming system and with a value chain perspective if efforts to mechanize agriculture in Africa are to be successful.

The following topics are covered by the main recommendations:

i. Integration of agricultural mechanization in Pan-African Policy Frameworks: At a pan-African level, there is a need to increase awareness of the potential benefits of agricultural mechanization for development. It is crucial to create appropriate policies that are regionally refocused and transnational in nature. An effective platform is provided by the Comprehensive Africa Agricultural Development Programme (CAADP) framework of the New Partnership for Africa's Development (NEPAD), which includes decision-makers from the African Union. The CAADP has a significant impact on how agricultural mechanization policies and plans are integrated at the national level.

ii. Sustainable Agricultural Mechanization Strategies: Incorporating off-farm uses can increase economies of use, therefore mechanization shouldn't be restricted to on-farm operations. Additionally, agricultural mechanization is beneficial when there is a real demand for agricultural outputs, including both on- and off-farm value addition. The entire agrifood chain must be taken into account in order to achieve sustainability, including how to finance the required capital investments (FAO, 2014b). It should be highlighted that automation technologies for agrifood chains aid in the reduction of waste, support the upkeep of rural infrastructure, and create job possibilities. Mechanization that is environmentally friendly increases output while protecting natural resources, particularly soil and water. Future mechanization models must follow the Save and Grow philosophy of the FAO.

iii. According to Save and Grow, agriculture must contribute to resource conservation, the provision of ecological services, and farmer productivity and profitability. Application of conservation agriculture on a large scale is necessary to maintain food supply as the negative consequences of climate change become more obvious. CA methods include input application of precise and efficient energy, soil protection, and water conservation. While sequestering carbon in tilled soil and protected forest areas, it is crucial to decrease the emission of GHGs during agricultural production. For many years, developing strategies for agricultural mechanization has been a major FAO activity (FAO, 2013c, 2013d). It is essential to create and carry out a plan for a continuous and coherent change in the use of agricultural mechanization, especially given the significant adjustments needed for sustainable agricultural mechanization. Referencing the FAO recommendations is recommended during the formulation process (FAO, 1988). Given the complexity of agricultural mechanization, it is crucial that the approach used be both participatory and systematic.

iv. Participatory workshops should be arranged throughout the process, starting with an opening workshop, to include the range of interested actors from all points along the agri-food value chain. There are four main processes in formulation (Figure 1). Sustainability is given the utmost importance throughout this procedure. Although the FAO guidelines have been adopted by the Regional Network for Agricultural

Machinery (RNAM) in Asia and used in a number of other countries in Asia and Africa, it is difficult to determine the efficacy of the strategies created because the program has not been specifically evaluated (FAO, 2014b). The initial rules must be updated in order to meet the unique demands of the contemporary mechanized needs, particularly with regard to sustainability. The goal is to create Sustainable Agricultural Mechanization Strategies (SAMS) that satisfy the needs of various nations [3]–[5]. In Figure 1 shown the Progressive steps in the formulation of an agricultural strategy.

Figure 1: Progressive steps in the formulation of an agricultural strategy.

Step 1: Entails a detailed investigation of the circumstance, with specialists concentrating on their own area of expertise.

Step 2: Opinions on the current situation will be gathered at a second participatory workshop.

Step 3: The design of the strategy and action plan, in line with the national development objectives and policies improved during a third workshop, is step three.

Step 4: Entails developing a portfolio of project profiles and further defining the plan. At the end of the workshop, the results are given to the participants.

i. **Sustainable Agricultural Practices for Smallholders:** In especially at the smallholder level, agricultural mechanization can significantly enhance the utilization of natural resources and the overall "greening" of agriculture. Smallholders can increase yields by using intensification, conservation agriculture, and other climate-resilient, labor- and energy-efficient, and gender-friendly practices thanks to mechanization technologies. Importantly, mechanization also makes it possible to practice farming rationally and effectively over the long haul, boosting the likelihood of sustained profitability over time and promoting smallholder systems' long-term sustainability and ecosystem resilience. Many African nations have successfully implemented the FAO farmer field school (FFS) methodology in the framework of integrated pest management. The FFS idea has room to grow to cover topics including field-level support for small-scale mechanization and sustainable intensification (FAO, 2015c). To help local communities adapt to the dangers posed by climate change, for instance, tools and mechanized technologies could be implemented. Contrary to popular belief, agricultural mechanization technologies must be included in FFS or farmer-group-based investment decisions in order to achieve sustainability. The FFS method can assist shift this perspective. To achieve this, a well-run FFS might serve as the hub for creative financial initiatives like "matching grants" or "village savings and loan groups [6], [7].

ii. **Specific Business Models for Smallholder upscaling:** Smallholders frequently operate at the periphery of agrifood value chains and struggle to carve out a place for themselves in contemporary food systems. With more dependable supply, larger volumes of produce, on-time deliveries, and value addition, the discovery and specification of suitable business models for smallholder mechanization can open up a number of opportunities for greater access to and integration in agrifood value chains.

iii. **Economic Advantages of Mechanization for Smallholders:** It's critical to locate models that can contribute to the growth of the smallholder sector while also benefiting farmers economically. There is a ton of evidence to suggest that farmers who have quality and strong yields due to mechanization and therefore larger revenues tend to spend their new riches rather than reinvest it in their farms. Small-scale farmers need direction on how to strengthen their financial position through investments in productive revenue-generating assets and equipment repair and maintenance. For instance, it makes sense to invest in machinery that can perform a variety of tasks since, in addition to the ability to sell services to other farmers, the various operations have a strong chance of generating profitable results. Rest of the points will be discussed in the next section [8], [9].

DISCUSSION

Small-scale farmers may benefit from social opportunities (and results) brought about by agricultural mechanization. It can lower the risk of low yields through enhanced cropping intensity, timely planting, weed management, and harvesting, as well as by facilitating storage. This would improve the farm family's food security and nutrition. Small-scale farmers can diversify their income sources thanks to mechanization because they can now provide services to other local farmers and stop depending just on crops for cash. As a result, there may be more social harmony and wellbeing in local communities and social relationships will be strengthened. In remote rural locations, inadequate infrastructure and a lack of transportation are significant obstacles. By providing transportation for rural residents and their produce, agricultural mechanization can increase mobility and open up new economic prospects. As smallholder farm families grow more empowered and have more time to look for off-farm employment options, there may also be prospects for a change in gender dynamics [10].

The feminization of agriculture presents a number of sustainable prospects for enhanced agricultural mechanization at the farm level and throughout the agrifood value chain. In terms of managing natural resources, women are typically skilled. Given the current state of climate change and the depletion of natural resources, it is crucial to combine women's knowledge with the use of suitable farm machinery created specifically for use by women farmers in order to increase the environmental sustainability of food production. Just two of the potential benefits of adequately adapted and culturally and socially sensitive mechanization are reducing drudgery for women and speeding up farm and home operations. Women's access to and control over resources, along with cultural norms, attitudes, and presumptions, are just a few of the barriers preventing them from adopting technologies, though. Access to resources may be made easier by addressing local norms and values as part of interventions to assist the adoption of mechanization. According to studies, farm production would increase by 20–30% if women had equal access to productive resources to males (FAO, 2011b).

Therefore, it makes sense to think about how women can have access to or influence over resources used for mechanization (Figure 2). The "feminization" of mechanization, which enables women's access to it, calls for a theory of change that considers a wider range of barriers that women confront in addition to technological ones. After dealing with these limitations, technology should be the main focus. Young girls must first and foremost have access to education. Once this is accomplished, it is crucial to actively participate in the discussion of local norms and presumptions, which promotes the creation of groups, promotes cooperation, and makes it easier to gain access to and control over resources. The goal is to provide women-centered labor-saving mechanization technologies at production and other stages in the

agrifood value chain. The focus can then shift to women's requirements in terms of technologies and their corresponding design characteristics.

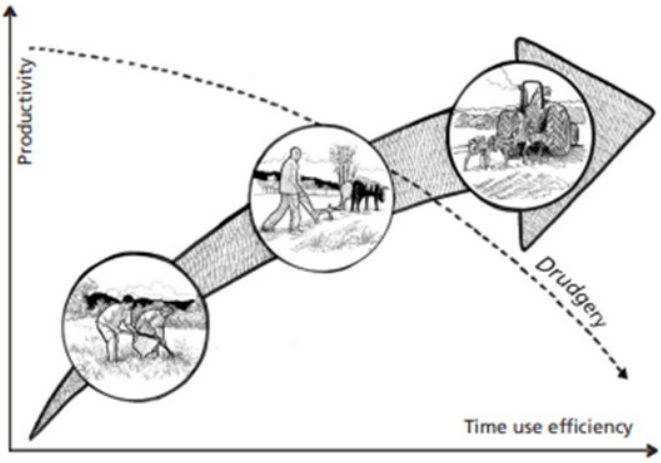


Figure 2: Agricultural mechanization and it's potential to reduce the drudgery of hand-powered efforts and increase labor and agricultural productivity.

The "feminization" of mechanization, which enables women's access to it, calls for a theory of change that considers a wider range of barriers that women confront in addition to technological ones. After dealing with these limitations, technology should be the main focus. Young girls must first and foremost have access to education. Once this is accomplished, it is crucial to actively participate in the discussion of local norms and presumptions, which promotes the creation of groups, promotes cooperation, and makes it easier to gain access to and control over resources. The goal is to provide women-centered labor-saving mechanization technologies at production and other stages in the agrifood value chain. The focus can then shift to women's requirements in terms of technologies and their corresponding design characteristics.

Institutional and Organizational Arrangements for Increased Smallholder Mechanization: Smallholders who band together for instance, in producer organizations have better access to prospects for agricultural mechanization. More knowledge sharing, stronger bargaining position, increased value addition, and more opportunities to maximize agricultural mechanization and realize its full potential will all help to improve commercial farming and facilitate further integration into contemporary agrifood systems. The foundation for integrating smallholder farmers into contemporary food systems is agricultural mechanization. Mechanization is not only useful on farms; it also plays a significant part in value addition through enhanced post-harvest operations, as well as processing and marketing activities. Additionally, it shortens the gap between harvest and consumption, giving marketing additional time.

It is possible to increase the manufacturing base for agricultural mechanization in Africa as well as create opportunities for more South-South cooperation among manufacturers, dealers, and institutions by supporting private sector development within the context of agricultural mechanization. Farmers that provide other farmers mechanization hire services might boost smallholder firms at the field level through private sector development. This results in increased farm yields as well as increased national demand for tools, equipment, and cars, generating a positive feedback loop. Knowledge-Sharing Platform: Common development lessons and experience-sharing within the framework of South-South Cooperation can build a

foundation for knowledge-sharing for increased agricultural mechanization in Africa. This could result in the transfer of knowledge and know-how about machinery, tools, and equipment, as well as the exchange of experiences on the use of models at the national and local levels that work or do not.

Sharing successful and unsuccessful agricultural mechanization policies and tactics can strengthen collaboration and encourage more specialized and targeted policies and plans. In terms of South-South Cooperation for the development of agriculture in Africa, China has a lot to contribute (Sims and Kienzle, 2016). Government initiatives to subsidize the purchase of agricultural machinery have considerably benefited China's smallholders, and the nation boasts top-notch extension services. China is one of the world's top producers of agricultural equipment, and the China-Africa Machinery Corporation, established by the YTO Group, focuses on technology transfer for the growth of smallholder farms in Africa. The construction of a sustainable agricultural mechanization center in Africa along the lines of Asia's United Nations Center for Sustainable Agricultural Mechanization (UN-CSAM) is another possible area of fruitful South-South cooperation.

Agricultural mechanization capacity building and development field-based approaches must be combined with tried-and-true training approaches. At the field level, farmer field schools (FFS) and farmer business schools (FBS) can incorporate agricultural mechanization. This not only serves as a solid foundation for the growth of smallholder competency in agricultural mechanization, but it also serves as a source of data and information for use in development projects, R&D organizations (national and international, public and private), and educational institutions like secondary vocational schools and universities throughout Africa.

SSA's current centers of expertise in agricultural mechanization, whether they be academic departments, research and testing facilities, or agricultural engineering institutes, must continue to receive encouragement and support. Regional centers of excellence, however, are also required in order to direct national policy toward sustainable agricultural automation. These centers of excellence can conduct R&D, machinery testing, and training whenever considered suitable and beneficial for the private sector, working closely with farmers, other value chain players, manufacturers, relevant private-sector stakeholders, and national government entities. To avoid researching ideas (farming methods and machinery) that remain at the prototype stage, it is crucial that the centers concentrate on the interests of the stakeholders. It's critical to consider the future users of the gear throughout the testing phase. The Asian United Nations Centre for Sustainable Agricultural Mechanization (UN-CSAM) (UN-CSAM, 2016) is a fascinating case study.

The enormous agricultural machinery industry in Asia needs incentives to produce machinery for environmentally friendly mechanized farming methods. Under the direction of the Beijing-based UN-CSAM of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), the Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) oversees national and regional standards and testing facilities. Given the global drop in agricultural engineering training and education programs, capacity building for SAMS implementation is a crucial task. Youth-centered capacity building incorporates gender and natural resource conservation as well as other aspects. Through extensive information exchange, knowledge sharing, and promotion of R&D and agri-enterprise development in the areas of sustainable agricultural mechanization and technology, the UN-CSAM objectives are to enhance technical cooperation among members and associate members of UNESCAP as well as other interested Member States of the UN, in order to achieve the regionally agreed-

upon development goals, including the SDGs. By concentrating on the following areas, UN-CSAM accomplishes the aforementioned goals:

i. Support for the development of sustainable agricultural mechanization and agricultural engineering.

ii. Enhancement of farm mechanization technology in resolving issues related to subsistence farming.

iii. Improving food security and reducing poverty by fostering the growth of commercial farming and agri-based small and medium-sized enterprises to take advantage of opportunities for expanded market access and agrifood trade.

iv. Promotion of an agri-based enterprise cluster idea and business development initiatives to improve members' capacity to recognize prospective agricultural products in their different nations on the basis of clustering.

v. Regional cooperation in the transfer of green agritechnology, including networking of focal point national institutes in UN-CSAM member nations and other pertinent organizations.the creation of an interactive Internet site that will give users full access to technology databases and information, including the sharing of expert systems and decision support systems for small- and medium-sized business financial management.

vi. Improving outreach services, particularly extension, training, and demonstration services, at the field level in SSA nations.

vii. Support for the process of technology transfer from research and development organizations to agricultural and farm machinery extension systems in member nations for the purpose of reducing poverty.

viii. Assistance with the sharing and dissemination of drawings of suitable tools, machines, and equipment, as well as sustainable and economically viable machinery.

ix. Execution of technical support projects, capacity-building initiatives, educational seminars and workshops, and advisory services on sustainable agricultural mechanization and associated food safety requirements.

x. Creating access to developed-country resources in order to increase member countries' capacity.

xi. Developing economic, commercial, financial, marketing, and entrepreneurial capacity in relation to agricultural mechanization.

xii. To develop such centers across Africa with a focus on appropriate sustainable mechanization and embracing the entire agri-food value chain in its purview, the UN-CSAM model can be adopted.

CONCLUSION

In conclusion, promoting agricultural mechanization through the suggested activities can open the door for considerable sector developments. Sub-Saharan Africa can overcome obstacles and fully utilize the potential of agricultural mechanization by developing supportive policies, investing in research and development, bolstering extension services, facilitating access to finance, promoting knowledge sharing and capacity building, strengthening infrastructure, and

encouraging public-private partnerships. These efforts will promote sustainable farming practices, stimulate economic growth, and improve livelihoods in addition to raising productivity. To properly execute these measures and unleash the revolutionary potential of agricultural mechanization in the area, cooperation and commitment are needed from governments, businesses, development organizations, and farmers.

REFERENCES

[1] M. D. Beer, "Cannabis and mental health," J. Psychiatr. Intensive Care, 2007, doi: 10.1017/S1742646407001045.

[2] L. Weischer, J. Morgan, and M. Patel, "Climate clubs: Can small groups of countries make a big difference in addressing climate change?," Rev. Eur. Community Int. Environ. Law, 2012, doi: 10.1111/reel.12007.

[3] K. C. Sivris and S. Leka, "Examples of holistic good practices in promoting and protecting mental health in the workplace: Current and future challenges," Saf. Health Work, 2015, doi: 10.1016/j.shaw.2015.07.002.

[4] P. McManners, "The action research case study approach: A methodology for complex challenges such as sustainability in aviation," Action Res., 2016, doi: 10.1177/1476750315597979.

[5] N. Tasnim, M. Islam, and J. H. Baek, "Deep learning-based action recognition using 3d skeleton joints information," Inventions, 2020, doi: 10.3390/inventions5030049.

[6] P. Beresford, "From psycho-politics to mad studies: learning from the legacy of Peter Sedgwick," Crit. Radic. Soc. Work, 2016, doi: 10.1332/204986016x14651166264237.

[7] T. Broodryk, "The South African class action mechanism: Comparing the opt-in regime to the opt-out regime," Potchefstroom Electron. Law J., 2019, doi: 10.17159/1727-3781/2019/v22i0a4506.

[8] H. Koers, D. Bangert, E. Hermans, R. van Horik, M. de Jong, and M. Mokrane, "Recommendations for Services in a FAIR Data Ecosystem," Patterns. 2020. doi: 10.1016/j.patter.2020.100058.

[9] J. Madsen and S. Josephsson, "Engagement in occupation as an inquiring process: Exploring the situatedness of occupation," J. Occup. Sci., 2017, doi: 10.1080/14427591.2017.1308266.

[10] C. Coker and J. Glynn, "Making college affordable," Paying Price Coll. costs, Financ. aid, betrayal Am. Dream, 2017.

CHAPTER 13

FARM MECHANIZATION AND LEVEL OF MECHANIZATION IN PUNJAB AND INDIA

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

Farm mechanization is a crucial aspect of modernizing agricultural processes, boosting output, and enhancing efficiency. It aims to maximize resource use, expedite operations, and replace or augment manual labor. In Punjab, India, farm mechanization has become increasingly important due to the need for higher agricultural productivity and the challenges faced by the industry. The goal is to reduce labor-intensive jobs, enhance operational efficiency, and boost agricultural yield. Mechanization also aims to alleviate farmer drudgery, address labor shortages, advance precision farming methods, reduce environmental impact, and optimize input use for sustainable agriculture practices. Punjabi, considered the "Granary of India," has significantly advanced farm mechanization in Punjab and throughout India. Mechanized tools, such as tractors, combine harvesters, and threshers, are frequently used in Punjab's agriculture. However, the degree of mechanization varies among different crops and areas of the state. Factors such as farm size, availability to credit and equipment, education levels, and cultural practices all impact the extent of mechanization. Government, agricultural organizations, and private sector organizations are working to advance farm mechanization in India through schemes such as subsidies, financial options, and training opportunities. To ensure widespread acceptance and equitable advantages, more development and mechanization are yet possible.

KEYWORDS:

Automation, Agricultural Machinery, Modernization, Productivity, Precision Farming, Mechanized Farming.

INTRODUCTION

Farm mechanization has emerged as a pivotal force revolutionizing the landscape of agriculture worldwide. It embodies the seamless integration of innovative technologies and advanced machinery into traditional farming practices, propelling the industry towards enhanced efficiency, increased productivity, and sustainable growth. With the global population on a relentless rise and arable land becoming scarce, the need for optimized agricultural practices has become more pressing than ever. In response to this challenge, farm mechanization offers a promising solution that empowers farmers to meet the demands of a growing population while reducing the burden on both the environment and labor force. Historically, agriculture has been deeply rooted in manual labor, relying on human hands and basic tools to till the land, sow seeds, and harvest crops.

However, as societies advanced and technological innovations blossomed, the incorporation of mechanization emerged as a transformative force. From simple plows to sophisticated tractors and autonomous drones, the evolution of farm mechanization has continuously shaped the way farmers interact with the land, ushering in a new era of smart agriculture. In this comprehensive exploration of farm mechanization, we will delve into the multifaceted aspects of this

agricultural revolution. We will examine the key technologies driving mechanization, including advanced machinery, robotics, artificial intelligence, and data analytics. Furthermore, we will explore the economic, social, and environmental implications of adopting mechanized farming practices, shedding light on the potential challenges and benefits faced by agricultural communities around the world [1], [2].

The journey into the realm of farm mechanization will take us on a captivating expedition through time, unveiling the milestones that have defined the agricultural sector's transformation. Moreover, we will witness the impact of mechanization on various crops and farming systems, from large-scale agribusinesses to smallholder farms, showcasing how this technological shift has democratized access to efficient farming methods. As we embark on this enlightening journey, we will gain a deeper understanding of the intricacies and advantages of farm mechanization. We will witness how it optimizes resource utilization, minimizes labor intensity, and maximizes yields, all while mitigating environmental impact and supporting sustainable agricultural practices. Join us as we unravel the possibilities and potential that farm mechanization presents, and discover how it has become the catalyst for reshaping the future of agriculture. From precision planting to remote monitoring and from autonomous harvesting to climate-smart solutions, the implementation of mechanized farming practices offers a profound opportunity to cultivate a bountiful and resilient future for farmers, consumers, and the planet as a whole [3]. Various agricultural activities carried out on a farm can be broadly categorized as:

i. Work that requires movement, such as planting, growing, harvesting, and transporting seeds,

ii. Stationary tasks such threshing, winnowing, cutting silage, grinding feed, and raising irrigation water. These tasks are carried out by many power sources, including people, animals, stationary engines, tractors, power tillers, electricity, solar power, and wind. Different types of electricity that are available for performing these processes are divided into:

A. Human ability

B. Animal strength

C. Mechanical Strength

D. Using electricity

E. Wind energy

Human Power: There are signs that the number of workers employed in agriculture is declining, which will likely lead to more investment in mechanical power and labor-saving technology in the future.

Labor (Human Energy) on Farms: In areas where the traditional system of agriculture is followed, labor is one of the most significant sources of farm power. On small farms, the farmer and his family provide a large share of the labor. The hired laborers are only used to cover peak and ongoing labor demands. Both labor use efficiency and productivity are very low on small farms with very little extra money to buy the right kinds of hand tools and equipment that is dragged by animals. Employing workers in a group when the order of tasks necessitates teamwork can increase labor utilization efficiency. Without a team, a single person would waste his or her resources, which could raise the cost of operating. For instance, a power

thresher operation requires constant teamwork to ensure the effective use of expensive resources, such as the thresher, cleaner, prime mover, etc.

Animal Power: The most significant source of power for farming operations worldwide, especially in developing nations, is animal power. According to estimates, animals still provide close to 80% of the total draft power utilized in agriculture around the world [4]. various animal sources include:

a. Bullocks can only pull roughly 15% of their own weight.

b. Buffaloes

c. Camels

d. Horses

e. Donkeys are capable of pulling 80% of their weight in a short time and 10% to 15% of their weight over an extended period.

f. Mules and,

g. Elephants

Bullocks have a maximum force that is almost a tenth of their body weight. But for a very brief time, it can exert many times greater force than usual. A medium-sized bullock typically produces 0.50 to 0.75 horsepower.

Mechanical Power

The mechanical power provided by tractors and stationary engines is the third crucial source of farm power. Engines are incredibly effective at turning fuel into usable work. Diesel engines have an efficiency range of 32 to 38 percent, compared to 25 to 32 percent for gasoline engines. Tractors and diesel engines have become increasingly common in agricultural activities in recent years. Small pumping sets between 3 and 10 horsepower are in high demand. Similar to how engines with low to medium speed and 14 to 20 hp are successfully utilized for oil expellers and grain mills, etc. Tractors use diesel engines that are greater in size. In agriculture, diesel engines are the predominant kind of power. Their preference is primarily due to the operating economics [5].

Wind Power

There isn't much wind power available for agriculture operations. Wind mills can be used to lift water where the wind speed is more than 32 km/h. Its uncertainty is the main cause of its low use. Therefore, a wind turbine's typical capacity would be 0.50 horsepower. It is one of the most affordable options for farm power.

Mechanization

Agricultural Mechanization: involves the creation, production, distribution, usage, and maintenance of all varieties of agricultural tools, machinery, and equipment. There are three main power sources: mechanical, animal, and human, with mechanical (tractive power) receiving special attention.

Farm Mechanization: relates only to operations that are often carried out inside the confines of the farm unit or at the farm unit level (for example: village, community, co-operatives, etc.) and is theoretically comparable to agricultural mechanization.

Tractorization: refers to the application of any size tractor to activities associated with agriculture.

Motorization: refers to the application of all types of mechanical motors or engines, regardless of energy source, to activities related to agriculture.

Agricultural Implements: are devices attached to, pulled behind, pushed, or otherwise used with human, animal or mechanical power source to carry out an agricultural operation.

Agricultural Machinery: is a broad term used to describe any more complex than hand tools, mechanically or animal-powered tractor, combine, implement, machine, or other device.

Agricultural Equipment: generally, refers to stationary mechanical devices such as irrigated pump-set [6], [7].

Scope of Mechanization

Due to their poor yield per hectare from their land holdings, it is true that farmers in emerging nations have the lowest profits per capita. Mechanization is one of the few significant ways to raise farm production per hectare. It might be necessary to automate at several levels. Generally speaking, there are three ways to go about it:

i. By making improved agricultural tools available for use on small farms with bullocks.

ii. By utilizing power tillers, small tractors, and tractor-drawn equipment on medium-sized holdings to supplement current sources.

iii. By supplementing the animal power source with the heavy tractors and equipment on the remaining estates.

In actuality, the degree of farm mechanization (output per worker and the horsepower under his control per unit area) should be the primary factor used to evaluate the growth of the nation. Mechanization is strongly encouraged by the large amount of labor or draft power that can be substituted by machines [8], [9].

DISCUSSION

Farm Mechanization:

Farm mechanization is the use of technology and engineering in agricultural operations to perform tasks more effectively and increase output. The creation, management, and use of all mechanical aids for field production, water control, material handling, storing, and processing are included in this. Hand tools, machinery pulled by animals, power tillers, tractors, engines, electric motors, and processing and hauling equipment are examples of mechanical aids.

Scope

Due to the following reasons, agriculture mechanization in India has a positive future:

i. The nation's irrigation infrastructure has been improved.

ii. The introduction of seed types with high yields.

iii. The application of excessive doses of insecticides and fertilizers for various crops.

iv. The introduction of new crops in various regions of the nation.

v. Different regions of the country use an intensive cultivation strategy and multiple cropping systems.

Some Other Factors which are responsible to encourage farm mechanization are:

i. The population of the nation is growing at a rate of roughly 2.2% annually. To provide food and fiber for such a huge population, the nation must adopt intensive farming practices. Machines are needed on the farm for intensive farming.

ii. All farm operations must be accomplished in a short amount of time with economy and efficiency when using high yielding varieties of seeds in repeated cropping programs. This is made possible via mechanization.

iii. Farm mechanization significantly reduces labor drudgery. When using bullocks to plow a 1 ha field once with a country plough that has a 15 cm furrow width, a farmer must travel around 66 kilometers on foot.

iv. Many girls and young children work on farms. Therefore, thanks to automation, women can work from home while their kids attend school.

v. With the right tools, it will be possible to use fundamental inputs like water, seeds, and fertilizers in the right ways.

There are some tasks that are exceedingly challenging to complete with either human or animal labor, such as:

i. In the case of deeply rooted crops, deep plowing.

ii. Deep tillage operations to eradicate the harmful weeds.

iii. Leveling up sloping terrain.

iv. Reclamation of land.

v. The use of insecticides during times of epidemics. These tasks require sophisticated mechanical equipment.

Benefits of Farm Mechanization

a) Farm mechanization has a number of advantages, including:
b) Operation in a timely manner.

c) Operational accuracy.

d) Enhanced working conditions.

e) Safety enhancement

f) Lessening of labor's drudgery

g) Reducing crop and food product losses

h) Enhanced land productivity

i) Greater financial gain for farmers

j) Increased respect for farmers

k) Development and success in rural areas

Present Status of Farm Mechanization

The current state of farm mechanization is quite encouraging. We possess

a) Better hand tools.

b) Instruments drawn by improved animals.

c) Tools powered by tractors.

d) On-farm custom hiring of equipment.

e) Other stationary equipment, such as shredders, sprayers, dusters, and irrigation pumps.

Limiting Factors in Farm Mechanization

a) Adopting farm mechanization has a number of drawbacks:
b) Limited and dispersed landholdings.

c) Farmers' reduced ability to invest.

d) Farmworkers are readily accessible.

e) The nation has enough animals for use as draft animals.

f) A lack of available farm equipment that is appropriate for various tasks.

g) Lack of machine maintenance and repair facilities.

h) A lack of skilled labor.

i) A lack of coordination between manufacturers and research organizations.

j) Exorbitant machine costs.

k) Insufficient machine quality control.

India has advanced significantly in the area of agriculture, increasing output from just 51 million tons in 1950–1951 to 258 million tons by 2011–2012. This has been accomplished by using biological, chemical, and mechanical inputs as well as by building the necessary infrastructure and amenities in rural regions and promoting their use. Appropriate government initiatives, including holding consolidation, land leveling, the construction of rural roads and grain markets, rural electrification, adequate finance, and the guarantee of a minimum support price, have contributed to this extraordinary rise in agricultural productivity. The well-planned Green Revolution in India has made the country proud. Since the middle of the 1960s, India has experienced numerous revolutions that have strengthened the foundation of our agrarian economy.

The four main ones are the Blue Revolution, the Grey Revolution, and the White Revolution. The last revolution is also known as the industrial revolution. The Indian green movement is waning, though. A plateau has been reached in the yields. The nation is currently looking for an evergreen or rainbow revolution. Low productivity in rainfed areas, declining soil fertility, receding water tables, changes in ecology brought on by monoculture and the indiscriminate use of resources, rising environmental pollution, staggering losses of perishables (30–40%), a

lack of scientific post-harvest infrastructures, insufficient energy for production and post-harvest agriculture, low exports due to low quality and high production costs, and many other issues plague Indian agriculture. The WTO regime has heightened the need for a paradigm shift in Indian agriculture and everyone's attitudes.

The new focus of Indian agriculture is ecologically sustainable agriculture, which includes the adoption of conservation farming, diversification of agriculture in problem regions, increased private investment, and establishment of chains of agro-processing facilities in rural areas. The central food reserve of the nation contains about 60 million tonnes of wheat and paddy, and urgent action must be taken to promote exports and provide food to nearly 40% of the population who lack access to it due to cost considerations, despite the fact that the nation has plenty of food in the reserve.

Policymakers, economists, sociologists, engineers, and everyone else involved in agricultural modernisation frequently conducted discussions in the 1960s and early 1970s over the applicability of agricultural mechanization in a labor-rich economy. The Planning Commission ordered numerous studies through the National Council of Applied Economic Research (NCAER), State Universities of Utah (SAUs), and other organizations to determine the effects of agricultural mechanization on agricultural productivity, cropping intensity, labor employment, and returns to farmers. These studies unequivocally shown that the use of tractors and farm mechanization increased cropping intensity significantly, increased production and productivity, and decreased production costs. Machines did replace labor for some tasks, such as harvesting, but when direct labor on the farm is added to indirect labor used for manufacturing, repair, maintenance, and subsidiary labor, farm mechanization resulted in a higher level of employment creation. The main benefits of farm mechanization include increased productivity, better quality operations, accuracy placement, uniform distribution, decreased losses, better produce quality, lower production costs, less drudgery for humans and animals, and increased respect for labor. It is now generally acknowledged that the development of tractors and other equipment has also assisted in preventing the emigration of educated young people and skilled and unskilled labor from rural to urban regions [10], [11].

India has done remarkably well in the mechanization of agriculture despite the extensive agro ecological diversity, variance in soil types, climate, precipitation, irrigation intensity, cropping systems, land topography, and industrial infrastructure. Utilizing both animate and inanimate forms of farm power, such as human labor, draft animals, tractors, diesel engines, and electric motors, we have developed a distinctive model through selective mechanization. Over 205 million agricultural workers, 63 million pairs of draft animals, 3.0 million four-wheel tractors, 110,000 power tillers, and over 18 million irrigation pumps are being employed by the nation's farmers. The availability of agricultural power per unit area (kW/ha) is one of the often used metrics to represent the degree of mechanization of agriculture in a state or country. It is 1.12 kW/ha for India, 2.96 kW/ha for Punjab, 2.33 kW/ha for Haryana, 2 kW/ha for Tamil Nadu, and 1.48 kW/ha for Uttar Pradesh, which is the most mechanized state in the country.

Every year, the FAO releases a Year Book that lists the number of tractors and harvesters per 1000 ha for all of the world's nations and continents. In India, there are currently 14 tractors per 1000 ha available, compared to 82 tractors per 1000 ha in the state of Punjab. In fact, Punjab takes great satisfaction in its role in India's development and adoption of farm mechanized technologies. In the late 1950s, the first stationary power sources (engines and electric motors for pumps, tube wells, and threshers) were used. Later, mobile power sources (tractors and combines) were used for a variety of field operations, from crop harvesting to land preparation. The first power thresher in India as well as tractor and animal-operated seed

drills, potato planters and diggers, sunflower threshers, seed planters, sugarcane planters, strip till drills, high clearance sprayers, straw combine, as well as various weeders, cleaners, graders, and vegetable seed extracting machines were all invented in Punjab in 1957. A crop or activity is always mechanized from Punjab, first in neighboring states, then throughout the entire country of India. Agriculture has been mechanized thanks in large part to the efforts of agricultural engineers, manufacturers, and farmers. In Figure 1 shown the Power availability, cropping, intensity, percent irrigated area, fertilizer consumption and grain yield for different states in India.

State	Annual rainfall (mm)	% Irrigated area	Power (kW/ha)	Fertilizer (kg/ha)	Cropping intensity	Grain equivalent yield (ton/ha)
Jammu & Kashmir	617	40.0	0.71	69.8	1.48	2.01
Himachal Pradesh	494	13.1	1.61	50.9	1.71	2.40
Punjab	555	93.7	2.96	299.5	1.80	5.26
Uttar Pradesh	837	64.7	1.48	150.6	1.49	3.58
Haryana	494	78.6	2.33	202.5	1.68	3.63
Rajasthan	421	29.3	0.53	39.2	1.20	0.93
Assam	1449	27.9	0.56	18.2	1.42	1.61
Bihar	1024	44.3	0.82	93.5	1.38	1.91
West Bengal	1355	24.7	1.21	158.9	1.65	3.11
Madhya Pradesh	1021	25.2	0.71	42.2	1.24	1.38
Gujrat	609	31.1	0.90	81.1	1.13	1.08
Orissa	1123	28.6	0.48	37.7	1.38	1.23
Maharashtra	920	13.4	0.78	76.6	1.24	1.28
Andhra Pradesh	594	40.8	1.18	158.9	1.21	1.83
Karnataka	802	24.9	0.80	90.2	1.15	1.58
Tamil Nadu	950	53.6	2.00	135.4	1.21	2.81
Kerala	1927	19.3	0.86	90.5	1.36	1.45
Total	880	38.3	1.02	97.6	1.32	1.96

Figure 1: Power availability, cropping, intensity, percent irrigated area, fertilizer consumption and grain yield for different states in India.

CONCLUSION

In order to increase agricultural output and efficiency, farm mechanization is essential. Mechanization has been introduced in Punjab and throughout India at varied rates and has been motivated by distinct goals. Farm mechanization is being introduced to help with major issues such labor shortages, expanding farms, and the need for efficient operations. Mechanization decreases reliance on human effort, boosts operational speed, and improves precision by substituting manual labor with machines. Punjab, renowned as the "Granary of India," has a considerably greater level of mechanization than other states. Particularly in the cultivation of commodities like wheat and paddy, the state has largely embraced mechanical processes. A considerable shift toward automated farming has occurred as a result of the government's numerous subsidies and incentives to encourage the use of machines. India has made tremendous progress in agriculture mechanization on a nationwide scale. To promote the use of mechanical agricultural techniques, the government has created a number of programs and projects. But because of things like differences in landholding sizes, economic inequalities, and cultural customs, the degree of automation differs across regions. Despite the many advantages of farm mechanization, there are also drawbacks, including expensive initial investment costs, remote locations' limited access to equipment, and the requirement for farmers to upgrade their skills. The incorporation of appropriate automation technology while maintaining traditional farming methods is essential to ensuring sustainable agricultural development.

REFERENCES

[1] G. P. Paudel, D. B. KC, D. B. Rahut, N. P. Khanal, S. E. Justice, and A. J. McDonald, “Smallholder farmers’ willingness to pay for scale-appropriate farm mechanization: Evidence from the mid-hills of Nepal,” Technol. Soc., 2019, doi: 10.1016/j.techsoc.2019.101196.

[2] P. S. Tiwari, K. Singh, R. K. Sahni, and V. Kumar, “Farm mechanization - Trends and policy for its promotion in India,” Indian Journal of Agricultural Sciences. 2019. doi: 10.56093/ijas.v89i10.94575.

[3] A. G. C, J.-H. Yeo, and K. Ghimire, “Determinants of Farm Mechanization in Nepal,” Turkish J. Agric. - Food Sci. Technol., 2019, doi: 10.24925/turjaf.v7i1.87-91.2131.

[4] G. P. Paudel, H. Gartaula, D. B. Rahut, and P. Craufurd, “Gender differentiated small-scale farm mechanization in Nepal hills: An application of exogenous switching treatment regression,” Technol. Soc., 2020, doi: 10.1016/j.techsoc.2020.101250.

[5] Ayandiji A and Olofinsao OT, “Socio Economic Factors affecting Adoption of Farm Mechanization by Cassava Farmers in OndoState, Nigeria,” IOSR J. Environ. Sci. Ver. I, 2015.

[6] M. U. Khan and T. U. Rehman, “Early trends, current status and future prospects of farm mechanization in Asia,” Agric. Eng. Int. CIGR J., 2019.

[7] C. R. Mehta, P. C. Jena, N. S. Chandel, and A. Jha, “Indian agriculture counting on farm mechanization,” AMA, Agric. Mech. Asia, Africa Lat. Am., 2019.

[8] T. Sengupta, G. Narayanamurthy, R. Moser, and P. K. Hota, “Sharing app for farm mechanization: Gold Farm’s digitized access based solution for financially constrained farmers,” Comput. Ind., 2019, doi: 10.1016/j.compind.2019.04.017.

[9] C. R. Mehta, N. S. Chandel, and Y. A. Rajwade, "Smart farm mechanization for sustainable indian agriculture," AMA, Agric. Mech. Asia, Africa Lat. Am., 2020.

[10] L. A. McCormack, T. L. Binkley, and B. L. Specker, "Effect of level of farm mechanization early in life on bone later in life," J. Musculoskelet. Neuronal Interact., 2012.

[11] J. P. Alex, "Powering the Women in Agriculture: Lessons on Women Led Farm Mechanisation in South India," J. Agric. Educ. Ext., 2013, doi: 10.1080/1389224X.2013.817342.

CHAPTER 14

MATERIALS OF CONSTRUCTION OF FARM EQUIPMENT

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

A variety of materials are used in the construction of farm equipment in order to suit various requirements. Steel, cast iron, aluminum, rubber, plastic, fiberglass, and wood are examples of common materials. Cast iron delivers stability and resilience for parts like engine blocks, while steel offers strength and longevity for heavy-duty machinery. Aluminum is suitable for some applications because it is lightweight and resistant to corrosion. Tires are made of rubber, which provide traction and stress absorption. Plastics are utilized for lightweight components because they are inexpensive and resistant to corrosion. For a variety of equipment, fiberglass combines strength and corrosion resistance. Even though it is less popular, wood is nevertheless used for some sections. The selection of materials is influenced by elements including price, needed levels of strength, and environmental circumstances. To ensure the best performance and durability of farm equipment, manufacturers frequently utilize a combination of materials.

KEYWORDS:

Agriculture, Construction, Equipment, Farm, Materials, Machinery**.**

INTRODUCTION

Broadly there are two groups of materials namely metallic and non-metallic Shown in Figure 1.

Metallic		Non-Metallic
Ferrous	Non-Ferrous	Wood (timber)
Iron: Cast iron Wrought iron	Copper (Cu)	Rubber
Steel: Steel Steel Alloys	Zinc (Zn)	Leather
	Lead (Pb)	Plastics
	Tin (Sn)	Fiberglass
	Aluminum (Al)	Teflon
	Brass (Cu+Zn)	
	Bronze (Cu+tin)	
	White metal or Babbit (Tin+Cu)	
	Solder (Tin+lead)	

Figure 1: Illustrate the two groups of materials namely metallic and non-metallic.

What is an Alloy?

It is an object that possesses metallic qualities and is made up of two or more chemical elements, at least one of which is a metal. There are countless different alloys. Metals are fused together to create them [1]. These are typical alloy subgroups:

a) Steels that are alloyed with manganese, chromium, nickel, tungsten, etc.

b) Non-ferrous alloys
   i. Bronze
   ii. Brass
   iii. Solder, babbit, or antimony
   iv. Alloys of aluminum

Classification of Steels:

Steel is an iron and carbon alloy. Steels are categorized based on:

a) The manufacturing process:
   i. Semco Steel
   ii. Hearth Steel Open
   iii. Elemental Steel

b) Carbon Composition:
   i. Low Carbon (0.25 percent or less)
   ii. (Easy to shear, bend, and forge)
   iii. (0.25% to 0.50% c) Medium Carbon Steel
   iv. Steel that is high in carbon (0.50 to 1.2% c)

c) Alloy steel, which is a combination of two or more chemical compounds, one of which is a metal.

d) In Line with Uses:
   i. Steel for Structures
   ii. Steel tool

e) Based on the Forming Method:
   i. Finished Steel
   ii. Iron and Steel
   iii. Forged steel
   iv. Created Steel

Purpose of Alloying Substances

a) **Manganese:** Used for cutting tools and high-grade ball bearings. It imparts hardness

b) **Chromium:** Same as manganese

c) **Tungsten:** Helps in maintaining sharp edge even when the cutting tool is hot.

d) **Nickel:** Helps in making steel elastic and ductile.

Application of Steel:

a) **Low Carbon Steel:** This material is often used to build farm equipment. Low-carbon steel is used to construct frames and the majority of other members.

b) Steel with a medium carbon content is used because it is stronger and harder. Steel with a medium carbon content is used to make members like shafts and connecting rods.

c) **High Carbon Steel:** This steel is extremely hard and is used to make tools, cutting tools, ball and roller bearings, etc [2].

Alloys Steels and Their Composition:

1. **Boron Steel:** Contains small amount (2.3%) Boron. Boron increases hardenability of steel. Parts Made: Axles, wheel spindles, steering nickel arms, cap screws, studs etc.

2. **Manganese Steel:** Contains 11-14% manganese and 0.8-1.5% carbon. It has extreme hardness and ductility. Can be cast in desired shapes and finished by grinding. Parts made: Machine parts subjected to severe wear e.g., feed grinders [3].

3. **Nickel Steel:** Contains 2-5% nickel & 0.10-0.5% carbon. They are strong, tough and ductile. Parts made: Used to make parts subjected to severe wear e.g. feed grinders

4. **Vanadium Steel:** Contains 0.20% vanadium. It is added for higher tensile strength and elasticity. Comparable to low and medium carbon steels.

5. **Chrome-Vanadium Steel:** Contains 0.5-1.5% chrome, 0.15-0.3% vanadium and 0.15-1.10% carbon. Parts made: Used for hard and malleable machinery casting, forgings, springs, shafts, gears and pins.

6. **Tungsten:** Contains 3-18% tungsten and 0.2-1.5% carbon. Parts made: used for dies and high-speed cutting tools [4].

7. **Molybdenum Steel:** Properties similar to tungsten steel.

8. **Chrome Steel:** Contains 0.5-2% chrome and 0.10-1.5% carbon. Parts made: used for high grade balls, rollers, races for ball and roller bearings. 14-18% chrome used to produce variety of stainless steels.

9. **Chrome-Nickel Steel:** Contains 0.3-2% chrome, 1.0-4.0% nickel and 0.10-0.60% carbon. Parts made: used for gears, forgings, crankshafts, connecting rods and machine parts.

10. **Stainless Steel:** Contains 16-18% chrome, 7-8% nickel and less than 0.15% carbon.

11. **Tool Steel:** Tool steel means high carbon steel which is used for making tools, It is extremely hard by quenching from a temperature of 800-850 degree celsius. Degree of hardness can be altered by heating at lower temperature [5].

In the next section we will discuss about more metals and some further processes.

DISCUSSION

Cast Iron

Additionally, it is an iron and carbon alloy. Carbon content ranges from 2.4 to 4.5%. It is extremely brittle and hard. Cast iron comes in five different general categories:

1. Cast iron that is grey in color and has a crystalline structure contains carbon in the form of graphite flakes.
2. White cast iron: When shattered, carbon stays in a chemically bonded form, giving it a distinctive white color.
3. Chilled Cast Iron: is created by rapidly cooling or chilling specific casting components. Slowly cooled parts show traits of gray cast iron, while chilled parts have characteristics of white cast iron. Using mould boards as an example, only one side has been hardened.
4. Cast iron that is malleable is produced via annealing, also known as "softening," or "softening" white casting. Cast iron is heated to a temperature of roughly 900°C, maintained in the oven for a suitable amount of time, and then carefully cooled. In contrast to the crystalline form found in the gray cast iron, this transforms the chemically bonded carbon into free carbon in a "amorlous" form. Malleable cast iron is strong, durable, and simple to work with in castings. Examples include chain links, ledger plates, clutch brake control pedals, and mower guards [6].
5. In 1949, malleable cast iron was created. By mixing magnesium alloy with molten iron that has been prepared to make gray cast iron, high-grade iron is created. When added in a controlled proportion, magnesium functions as a desulphurizer, producing spheroidal carbon rather than flake carbon (graphite), as in the case of gray cast iron. Examples include gears, plow shares, mower guards, hay-bailer knotter mechanism components, and sprockets [7].

Non-Ferrous Metals:

The following uses of non-ferrous metals and alloys are covered:

1. Copper (Cu): windings, wires, and other products

2. Cu (60–90%) and Zn (10–40%) are alloyed to form brass. used to make instrument parts, fuel line screens, brass welding rods, radiator pipes, etc.

3. An alloy of copper (80–95%) and tin (5–20%) makes bronze. Sometimes zinc is also added. used to create bushings, springs, valves, pump pistons, pipe fittings, and bearings.

4. Babbit: This is an alloy made primarily of tin, with minor amounts of copper (7-8%), antimony (8-9%), and tin (80-84%). utilized to create bearings.

Processes of heating and cooling can change or modify the properties of steel. "Heat treatment" is what this is. Hardening, tempering, annealing, case hardening, and other heat treatments are examples.

1. **Heat Treatment:** Inducing desirable qualities in metals and alloys in the solid state by combining heating and cooling operations in a certain way (with respect to time, temperature, and rate of heating & cooling). Heat treatment does not include typical heating used for hot working.

2. **Rate of Cooling:** Temperature decreases per unit time.

3. **Quenching:** Rapid Cooling

4. **Full Annealing:** Heat to a temperature over the transition range, hold it there for a while, then let it cool gradually through the transformation range. Huge internal stresses are created throughout the forging and casting manufacturing processes, either by the actual forging forces or by uneven cooling contraction. These tensions could cause castings to shatter when they cool if they are not relieved. The process of annealing involves heating the components to around 900°C for 30 minutes, after which they are removed from the furnace and allowed to cool in the oven very gently. If necessary, this step is carried done prior to hardening. It successfully eliminates internal tensions in materials [8].

5. **Case Hardening:** modifying the surface's composition to make it harder, then, if necessary, applying the appropriate heat treatment. Due to their relative softness, wrought iron and carbon steel (c less than 0.5%) cannot be significantly toughened with routine heat treatments. Case hardening is used to make them harder. This procedure makes it possible to create items that are both shockproof and incredibly hard on the surface. According to the needed depth of hard casing, the objects to be hardened are packed in iron boxes with carbonaceous material like animal charcoal or 3:1 wood charcoal + powered bones and heated to about 900°c for about 5 to 10 hours. The material's iron and carbon combine to form the hard cement, Fe3c. After cooling, the components are removed from the iron boxes, reheated independently to around 800°C, and quenched in cold water to harden the casings. Other case hardening techniques are numerous.

6. **Carburizing:** A method of adding carbon to the surface of solid pieces of steel by heating and retaining the metal in contact with a suitable carbonaceous media while it is kept above the transformation temperature.

7. **Flame Hardening:** Rapid surface healing using cold working or an oxy-gas flame at a temperature above the transformation range.

8. **Hardening:** any procedure that improves hardness, such as cold working or quenching from or above the transition range. Steel that has enough carbon (c more than 0.5%) can be toughened by heating it to 850°C (red color) and quenching it in water, brine, or oil. The harder the material becomes, the higher the carbon content (up to 1.2%). However, the material becomes extremely brittle after hardening, and it must be tempered to sustain shock loads. For a given steel, greater hardness and greater brittleness result from faster cooling. Oil cools more slowly than water, brine cools more slowly than water, and air cools the least slowly [9].

9. **Induction Hardening:** The act of hardening something by induction heating it at the right temperature and quenching it in the right medium.

10. **Nitriding:** A method of surface hardening that involves heating and keeping a suitable steel at the proper temperature while it is in contact with cracked ammonia or another acceptable nitrogenous liquid in order to introduce nitrogen into the surface.

11. **Normalizing:** A heat-treatment method used to enhance mechanical characteristics by fine-tuning grain and ensuring structural consistency. The procedure entails heating to an appropriate temperature above the transition range, frequently holding for a predetermined amount of time, and then allowing to cool naturally in air.

12. **Stress-Releiving:** After heating to a suitably high temperature below the transformation range and, if required, maintaining it there, the material is slowly cooled to only remove internal tensions. also known as stabilizing therapy.

13. **Tempering:** Steels that need to be hardened are heated to a high temperature that is below the transformation zone, held at that temperature for a predetermined amount of time, then slowly cooled to give the steels the appropriate mechanical qualities. It involves quenching the hardened steel components after they have been reheated to a temperature of roughly 500°C (blue). The material loses some of its hardness and the majority of its brittleness in this fashion. Farm machinery manufacturing now heavily relies on the hardening and tempering of its component parts. To achieve the required resistance to abrasion or bending, steel plough shares, cultivator points, and rake teeth are all heated under precisely controlled settings [10].

Case Hardening Methods

1. **Case Hardening:** Surface layer or case is hardened by heating the material to critical temperature (800°C), is exposed to carbon rich atmosphere, cooled and reheated to 200-500°C.

2. **Carburizing:** Steel is packed in pitch of charcoal. Is heated to 800°C, quenched and tempered.

3. **Nitriding:** Finished heat-treated steel parts are kept in an air-tight box and is heated to 800°C and ammonia is injected.

4. **Cyaniding:** When steel is briefly submerged in a molten bath of sodium cyanide, C&N are absorbed by the steel.

5. **Induction Hardening:** A brief period of high frequency alternating electricity is passed. On the surface, current is induced, which results in focused heating. Water is poured onto the heated surface to quench and harden the item.

6. **Flame Hardening:** Oxy-Acetylene torch is used to heat the surface quickly. Then quenched with water.

CONCLUSION

In conclusion, the materials of construction used in farm equipment play a crucial role in shaping the efficiency, durability, and overall performance of agricultural machinery. Throughout this exploration, we have delved into the diverse range of materials utilized in the fabrication of farm equipment, ranging from traditional choices like wood to modern advancements in metals and plastics. Understanding the significance of selecting appropriate materials is imperative for farmers, manufacturers, and agricultural engineers alike, as it directly impacts the equipment's reliability, longevity, and cost-effectiveness. In the agricultural sector, where machinery is subject to rigorous and often harsh conditions, the choice of materials becomes paramount. The right materials can withstand the wear and tear of daily use, weather extremes, and exposure to corrosive agents, ensuring that farm equipment continues to function optimally throughout its service life. Moreover, advancements in material science have opened up new possibilities for creating innovative, lightweight, and high-strength components, enabling the design of more efficient and sustainable farm equipment. Furthermore, as the world faces evolving environmental challenges, including climate change and resource scarcity, the careful selection of materials takes on an added dimension of importance.

Embracing eco-friendly materials and sustainable manufacturing practices can contribute to reducing the environmental impact of farm equipment and support the broader goal of sustainable agriculture. It is essential for stakeholders in the agricultural industry, including farmers, equipment manufacturers, researchers, and policymakers, to collaborate and leverage cutting-edge technologies and material advancements. By doing so, they can foster the development of even more resilient, efficient, and environmentally responsible farm equipment. As we navigate the complexities of modern farming and strive to meet the demands of a growing global population, the significance of the materials used in agricultural machinery remains at the forefront of progress. By harnessing the potential of advanced materials and embracing sustainable practices, we pave the way for a more productive, resilient, and sustainable agricultural future. The study of materials of construction for farm equipment is not merely an academic exercise but a vital step towards elevating the efficiency and sustainability of agriculture, ensuring food security, and promoting the well-being of farming communities worldwide. By staying abreast of the latest material innovations and engineering

practices, the agricultural sector can continue to evolve, thriving in its mission to feed the world while nurturing the health of our planet.

REFERENCES

[1] ASME, "ASME B31.4: Pipeline Transportation Systems for Liquids and Slurries," Am. Soc. Mech. Eng., 2019.

[2] ASME B31.4, Pipeline Transportation Systems for Liquids and Slurries. 2019.

[3] M. Simas and S. Pacca, "Assessing employment in renewable energy technologies: A case study for wind power in Brazil," Renewable and Sustainable Energy Reviews. 2014. doi: 10.1016/j.rser.2013.11.046.

[4] L. P. Kerkhove and M. Vanhoucke, "Optimised scheduling for weather sensitive offshore construction projects," Omega (United Kingdom), 2017, doi: 10.1016/j.omega.2016.01.011.

[5] S. Ji, C. Gao, B. Chen, and S. Li, "Carbon emission accounting for wind farm based on life cycle assessment," Shengtai Xuebao, 2016, doi: 10.5846/stxb201406111207.

[6] T. Babynets and Y. Tyutyunnik, "Economic Efficiency Of Design Solutions Of Livestock Farms," Tech. Technol. Asp. Dev. Test. new Mach. Technol. Agric. Ukr., 2020, doi: 10.31473/2305-5987-2020-1-28(42)-22.

[7] R. Sosa, Y. M. Díaz, T. Cruz, and J. L. De La Fuente, "Diversification and overviews of anaerobic digestion of Cuban pig breeding," Cuba. J. Agric. Sci., 2014.

[8] M. P. Weinstein and L. L. Weishar, "Beneficial use of dredged material to enhance the restoration trajectories of formerly diked lands," Ecol. Eng., 2002, doi: 10.1016/S0925-8574(02)00077-0.

[9] A. A. Arif, G. L. Delclos, L. W. Whitehead, S. R. Tortolero, and E. S. Lee, "Occupational exposures associated with work-related asthma and work-related wheezing among U.S. workers," Am. J. Ind. Med., 2003, doi: 10.1002/ajim.10291.

[10] P. Kic, "Effect of construction shape and materials on indoor microclimatic conditions inside the cowsheds in dairy farms," Agron. Res., 2017.

CHAPTER 15

AN OVERVIEW OF THE STATUS OF INSTITUTIONAL CREDIT

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

The current status of institutional credit within the financial landscape. Institutional credit plays a crucial role in facilitating economic growth, entrepreneurship, and poverty alleviation. The analysis encompasses an overview of the existing credit systems and explores their effectiveness in meeting the diverse needs of individuals, small businesses, and larger enterprises. Various factors affecting the accessibility and availability of institutional credit are explored, including regulatory frameworks, financial institutions' lending practices, and technological advancements. Furthermore, the abstract discusses the impact of institutional credit on financial inclusion, economic stability, and sustainable development. The findings highlight key challenges and opportunities for enhancing the reach and impact of institutional credit to promote inclusive and resilient financial systems in the present era.

KEYWORDS:

Economic Growth, Financial Inclusion, Institutional Credit, Lending Practices, Poverty Alleviation.

INTRODUCTION

One of the essential components for the growth of agriculture is credit. It provides farmers with funds to make new investments and/or embrace cutting-edge technology. The unique position Indian agriculture occupies in the macroeconomic system and the considerable contribution it makes to reducing poverty serve as further arguments for the significance of agricultural finance. Since India's planned development period began, there has been a strong focus on the institutional framework for agricultural credit because of the critical role that agricultural finance plays in promoting agricultural growth and development. The requirements of the farmers are met by a vast range of official institutional organizations, including cooperatives, regional rural banks, scheduled commercial banks, non-banking financial institutions, and self-help groups, among others. A number of actions have been done to improve the institutional framework of the rural lending sector. These programs' primary goal was to increase farmers' access to institutional financing.

Acceptance of the Rural Credit Survey Committee Report, nationalization of the largest commercial banks, the establishment of RRBs, the creation of the National Bank for Agriculture and Rural Development, financial sector reforms, the Special Agricultural Credit

Plan, the introduction of Kisan Credit Cards, the doubling of the Agricultural Credit Plan within three years, and the Agricultural Debt Waiver and Debt Relief Scheme are the major milestones in improving rural credit. The flow of agricultural financing was positively impacted by these activities. The insufficiency of financing to agriculture, however, is an often-contentious issue in India. It is nevertheless quite concerning that money lenders continue to dominate the rural loan sector. However, the majority of conversations on the subject of agricultural finance are often lacking in empirical support and are instead heavily influenced by emotions. In light of this, a study was conducted to assess the performance of institutional agricultural credit flow, including issues of equity in disbursement, and to determine the factors contributing to an increase in the use of institutional credit at the household level [1], [2].

Institutional credit is an essential part of the financial system that helps to reduce poverty, promote entrepreneurship, and enable economic progress. Access to credit from reputable financial institutions is essential for giving people, small companies, and bigger organizations the resources they need to achieve their objectives. Therefore, the state of institutional credit becomes a crucial aspect in assessing the health and vitality of economies all over the globe. This thorough investigation explores the state of institutional credit today, illuminating its many facets and ramifications. The report examines the efficiency of current credit systems in addressing the various and changing demands of borrowers by providing a comprehensive overview of these systems. Investigating issues including regulatory frameworks, lending policies used by financial institutions, and the impact of technology improvements on credit delivery systems, it looks at the availability and accessibility of institutional credit.

The availability of institutional loans is a critical factor that is being examined. While financial institutions serve as conduits for credit, a variety of variables may affect how much access people and companies have to these resources. The regulatory frameworks that determine the rules and regulations regulating the granting of credit have a considerable impact on how the lending environment is shaped. Analysing the present situation requires an understanding of how regulatory policies affect the availability of institutional credit. Additionally, financial institutions' lending policies have a critical role in determining the state of institutional credit. These procedures include loan approval standards, interest rates, required collateral, and repayment conditions. A thorough examination of lending policies will reveal the obstacles or enablers that borrowers face when applying for institutional credit. These perceptions may serve as a foundation for assessing the fairness and inclusivity of credit systems [3].

The position of institutional credit has undergone a radical transformation as a result of technological improvements. Traditional credit channels have been challenged by the growth of digital platforms, fintech developments, and alternative lending models, opening up new opportunities for borrowers. Understanding the modern credit environment requires an understanding of how technology developments have affected the availability, effectiveness, and risk management of institutional lending. Furthermore, the state of institutional credit has a significant impact on sustainable development, economic stability, and financial inclusion. Access to credit may enhance the quality of life for disadvantaged people and communities by allowing them to engage in economic activity. Entrepreneurship and innovation are encouraged by a healthy credit environment, which promotes economic expansion and employment creation. Furthermore, it is crucial to look at the state of institutional credit via a sustainability

lens since sustainable development objectives are intimately related to the accessibility of finance for green activities.

This in-depth investigation tries to illuminate the complex nature of institutional credit by assessing its present state and highlighting its main prospects and difficulties. Policymakers, financial institutions, and stakeholders can collaborate to expand the reach and impact of institutional credit by being aware of the strengths and weaknesses of the current credit systems. This will ultimately lead to the development of more inclusive, resilient, and sustainable financial systems that will benefit societies all over the world [4].

Pushing Policy Reforms-Challenges Ahead

RBI and NABARD have implemented a number of institutional and regulatory changes to address the issue of defaults and guarantee the financial stability of the rural banking industry. Recapitalizing regional rural banks, liberalizing interest rates, increasing the commercial flexibility of RFIs and credit flows to rural regions, and developing local area banks are the primary improvements made, especially after the financial reforms of 1991 took effect. The introduction of "Klsan Credit Cards" is seen as another excellent measure for delivering loans quickly and preventing defaults. These actions have helped regional rural banks and commercial banks in certain ways to improve their standing. Now, efforts are being made to revitalize cooperatives by adopting a "member driven approach," granting them more autonomy, reorganizing them at the village level, and offering incentives to bank employees and borrowers for prompt loan recovery and timely payback. Along with these actions, NABARD has also developed a microfinance program via the creation of Self-Help Groups with the assistance of non-governmental organizations operating at the village level. The program's primary goal is to raise the living standards of low-income rural families through expanding non-farm activities. The initiative has made significant strides in terms of SHGs created via RFIs, loans extended, decreased transaction costs, almost 100% loan recovery, and improvements in members' socioeconomic position. A few states have already passed laws allowing MF inclusion within RFIs' primary lending operations.

However, it is still unclear how quickly the program can be implemented within and across states to non-farm as well as agricultural operations, and if the program will be financially viable in the long term. The study concludes that the Indian SHGs program is still in its experimental stage and has not been fully empirically examined. Therefore, it is impossible to draw any firm conclusions about the RFIs' relative effectiveness over the long term. We have discussed a few components of the program by contrasting the results of productive foreign microfinance projects. The Bank for Agriculture and Agricultural Credits in Thailand, the Badan Kredit Kacamatan and the Bank Rakayat Indonesia Unit Desa in Indonesia, and the Grameen Bank in Bangladesh are four notable success stories in three developing Asian nations.

A comparison of the results of these chosen RFIs and the Bank-SHGs program shows that group financing for microfinance in India has significant potential. However, the RFIs must go a long way in addressing various concerns and simplifying the program within the context of their regular loan operation. Fast replication of it both inside and across states seems to be a difficult problem. The capacity of RFIs and NGOs to establish homogenous groups, distribute loans, and overcome obstacles relies in large part on the coordinated activities of the

government, banks, and NGOs engaged, the socioeconomic situation in a given area, and the ability of these organizations to do so. The success of the program would also depend on the availability of mobile banking services, incentives for bank employees and borrowers, third-party incentives, fines for subpar recovery performance, effective oversight by the bank staff, and the expansion of marketing and other services.

It is noted that the program itself is not focused on agricultural financing in terms of the application of SHGs to farm operations. However, this issue becomes more significant when considered in the broader context of the agricultural sector's high demand for credit, the similar group lending principles followed by SHGs and cooperatives, the relatively lower default rates for SHGs, the commercialization of agricultural activities, and the inability of RFIs to meet farmers' needs. The research concludes that incorporation of the SHGs model inside the PACS would be necessary if the MP were to be used to agricultural financing. Additionally, revitalizing RACS in a manner akin to microfinance organizations might be a difficult endeavour.

It would first require making changes to the current structure and working method with the least amount of bureaucracy, grouping members, teaching them the new working method, linking up their savings with loans, and defragmenting interest rates. The initial infusion of resources by the state or government into RFIs, employee desire to adopt a banking culture, prompt monitoring, and loan collection would be further variables. It goes without saying that the social and political backdrop of the program, as well as the freedom provided to RFIs in making necessary alterations, will all affect the design, application of group financing, and performance of the RFIs. Several of these concerns, including the size of the group formation, the reaction of the current members, the cost of group loans, seasonal loan distribution procedures, etc., ought to be experimentally examined and experimented with before going any further. The four Asian MF cases' information might point the way in this respect [5], [6].

Micro-Finance for Agriculture

The Bank-SHG MF looks to be promising in lowering transaction costs and attaining improved levels of loan recovery, as was already highlighted. However, if PACS adopted a similar strategy for agricultural funding, it would not only take a lot of time but would also force changes in their whole structure and operation. Therefore, we have proposed trying out community banking on different but related grounds. The concept is born out of the shifting dynamics of the rural agricultural economy, which are defined by activity diversification, the interdependence of the credit and input-output markets, the incapacity of RFIs to provide loans for a variety of activities, and the continued significance of informal agencies.

We have maintained that until a framework is put in place that injects credit into the agricultural sector on a sustained basis, farmers will continue to rely on informal agencies. Therefore, it is suggested that NABARD undertake two more institutional changes in addition to the MF strategy. The offered methods or models may or might not take SHGs' path into consideration. According to the first model, loans should be distributed via non-banking financial institutions like BASIX and SHARE, dealers in input and output, merchants, moneylenders, or other unofficial organizations with a presence in rural regions. These organizations, which are present in practically every area, may take an active role in the lending industry.

To start, NABARD might provide them financial assistance for expanding their infrastructure and meeting other needs. A cluster technique may be used to operationalize another strategy. An innovative institutional framework, known as the "Super Market Model" for the farmers, is developed at one location as part of comprehensive institutional reforms for the agricultural sector by creating links among all the important intermediaries involved in agriculture commerce. With initial financial assistance from the NABARD and the RFIs, some NGOs or NBFIs might be asked to take the lead in establishing and running this model. It is advised that a pilot project be started first on a trial basis in one particular area [7], [8].

Characteristics of the Status of Institutional Credit

Several crucial characteristics that describe institutional credit's standing and how it operates in the financial system today. These traits aid in understanding the nature and dynamics of credit systems as well as their advantages, disadvantages, and potential areas for development. The state of institutional credit has the following significant characteristics:

i. **Accessibility:** The ease with which people and organizations may receive credit from official financial institutions is referred to as the accessibility of institutional credit. It includes elements like eligibility standards, collateral needs, and the accessibility of credit to underdeveloped regions or underrepresented groups. The degree of accessibility demonstrates how inclusive credit systems are and how well-equipped they are to meet the various demands of borrowers.

ii. **Availability:** The supply of credit inside the financial system is what is meant by availability. It displays the readiness of financial institutions to provide loans to people and companies. Credit availability is impacted by a number of variables, including lenders' risk tolerance, market circumstances, legislative frameworks, and the state of the economy as a whole. Assessing the ability of financial institutions to satisfy credit demand requires a thorough understanding of credit availability.

iii. **Affordability:** The cost of borrowing is what is meant by affordability for borrowers. It takes into account things like interest rates, fees, and other costs related to credit transactions. The financial load on borrowers and their capacity to repay loans without falling into financial trouble depend on how affordable institutional lending is. Maintaining a viable credit environment requires finding a balance between appropriate profits for lenders and affordable borrowing prices for borrowers.

iv. **Risk Management:** Institutional credit must have effective risk management. Financial institutions evaluate and control all lending-related risks, such as credit risk, operational risk, and market risk. Effective risk management procedures make guarantee that credit is given to deserving applicants while reducing the likelihood of default and monetary losses. The stability and soundness of credit systems must be maintained via the use of effective risk management frameworks.

v. **Regulatory Frameworks:** Regulations, rules, and policies that control how financial organizations provide credit are referred to as regulatory frameworks. These frameworks attempt to safeguard consumer interests, encourage fair lending practices, and guarantee the stability of the financial system. Institutional credit operations are significantly impacted by the features of regulatory frameworks, such as their transparency, flexibility, and compliance with international norms.

vi. **Technology Integration:** Institutional credit increasingly demonstrates the incorporation of technology into its credit processes. The digitalization of credit application, underwriting, and disbursement procedures has been made possible by technological improvements. Integration of technology has the ability to improve efficiency, lower costs, increase access to credit, and expedite credit delivery. Different countries and financial organizations have different levels and degrees of technological integration in their credit systems.

vii. **Impact on Economic Growth:** Economic development is directly impacted by institutional credit. Credit encourages investment, entrepreneurship, and job development by giving people and companies access to the money they need. The amount of credit available and how it is distributed across productive industries have an impact on a nation's overall economic performance. Therefore, macroeconomic variables like GDP growth, employment rates, and company expansion are affected by the position of institutional credit.

viii. **Financial Inclusion:** The level of access that people and companies have to a variety of financial services, including credit, is referred to as financial inclusion. Financial inclusion and institutional credit have a strong relationship since it affects how easily underserved or unbanked people may access formal credit channels. An important goal of improving institutional credit is promoting financial inclusion via inclusive lending policies, specialized products, and focused outreach initiatives.

In conclusion, the accessibility, availability, affordability, risk management techniques, legal frameworks, technological integration, influence on economic development, and contribution to financial inclusion are the features of the status of institutional credit. Understanding these traits may help to enhance credit accessibility, efficiency, and inclusiveness by shedding light on how credit systems work and how efficient they are [9], [10].

DISCUSSION

A number of important factors that illuminate the condition of credit systems today, their ramifications, and prospective reform areas are the focus of the debate on institutional credit. In-depth analysis of these elements is provided in the next part, along with information on the usability, efficacy, and implications of institutional credit. The availability of institutional financing is a key topic of debate. By giving people and companies the resources, they need to invest, develop, and innovate, access to credit plays a crucial part in fostering economic growth and eliminating poverty. However, for many people, particularly those who come from underprivileged or marginalized groups, obtaining institutional credit may be difficult. People's ability to get credit from formal financial institutions may be hampered by elements including strict qualifying requirements, a lack of collateral, and poor financial knowledge. In order to guarantee that credit is available to all facets of society, addressing these obstacles and encouraging inclusive lending practices become essential. Another crucial topic of debate is the efficiency of institutional credit. Effectiveness includes a credit system's capacity to satisfy the various requirements of borrowers, support economic development, and foster financial stability. An effective credit system should be able to distribute credit effectively, guiding funds toward beneficial applications that provide returns on investment. Examining elements like loan performance, payback percentages, and the influence of credit on borrowers' financial stability are all part of determining how successful institutional credit is. Policymakers and

stakeholders may see opportunities for improvement and put measures in place to increase the efficiency of credit systems by looking at these metrics.

The position of institutional credit is greatly influenced by the regulatory frameworks that are in place. Various facets of credit supply, including as interest rates, loan terms, risk management procedures, and consumer protection measures, are governed by regulations. Examining regulatory frameworks' effects on credit availability, accessibility, and fairness is the goal of the debate around them. It's critical to strike the correct balance between promoting credit availability and guaranteeing financial stability in order to create a regulatory framework that supports responsible lending and safeguards borrowers' interests. The state of institutional credit has recently been considerably impacted by technological improvements. The breadth and reach of credit systems have increased as a result of the development of digital platforms, fintech advances, and alternative lending methods. Faster credit evaluations, simplified application procedures, and inclusion of people and companies who were previously underserved have all been made possible by technology-enabled solutions. The debate also looks at possible hazards and difficulties brought on by technology improvements, such as data privacy issues, cybersecurity dangers, and the digital divide that can prevent certain societal groups from obtaining credit.

Furthermore, an important topic of debate is how institutional credit affects financial inclusion, economic stability, and sustainable development. In order to support their economic activities, people and enterprises need have access to a variety of financial services, including loans. The topic is explored in detail, including how institutional credit may aid in fostering social and economic inclusion, empowering marginalized areas, and lowering income disparity. The effect of credit on economic stability and sustainable development is also explored, with an emphasis on the ways in which credit may assist green projects and promote long-term economic resilience. In conclusion, the debate of institutional credit status covers a wide range of topics, such as accessibility, efficacy, legal frameworks, technology improvements, and impact. Stakeholders may build focused interventions, identify strengths and weaknesses in credit systems, and create an atmosphere that supports inclusive, sustainable, and resilient credit ecosystems by critically analysing these factors.

CONCLUSION

The state of institutional credit has a big impact on people, companies, and whole economies. This thorough investigation of institutional credit has illuminated a number of issues, including accessibility, efficacy, legal frameworks, technology developments, and impact. Through this investigation, a number of significant conclusions have come to light, offering perceptions into the present condition of credit systems and possible directions for change. One of the key conclusions is that many people and enterprises, especially those from disadvantaged or underprivileged areas, still struggle to get institutional financing. They are hampered in their capacity to get loans from reputable financial institutions by obstacles such severe qualifying requirements, a lack of collateral, and poor financial knowledge. To solve this, policymakers and stakeholders must give top priority to initiatives to advance inclusive lending practices, increase financial literacy, and create cutting-edge strategies that meet the various demands of borrowers. Institutional credit's efficacy has also been called into question. There is potential for improvement even though credit systems attempt to distribute resources effectively and promote economic progress. Analyzing the effectiveness of loans, the frequency of payments,

and the effect of credit on borrowers' financial stabilitybeing may direct initiatives to increase the efficiency of credit systems. This entails promoting ethical lending practices, putting risk management controls in place, and assisting financial institutions in their endeavors to provide customized financial solutions.

Regulations have a significant impact on how institutional credit is seen. It's critical to strike the ideal balance between expanding loan availability and safeguarding financial stability. The correct policies should promote responsible lending, safeguard the rights of borrowers, and promote an atmosphere that is open to competition and innovation. To make sure that regulatory frameworks are successful in fostering the development of equitable and sustainable credit systems, they must be regularly evaluated and improved. The credit environment has undergone significant transformation as a result of technological improvements. Fintech developments, digital platforms, and alternative lending models have increased credit availability and efficiency. To guarantee that technology innovations benefit all people and organizations, it is crucial to manage related concerns including data privacy, cybersecurity, and the digital divide. Harnessing the full potential of technology to elevate the standing of institutional credit requires embracing new technologies while protecting consumer interests. Finally, it is impossible to overestimate the influence of institutional credit on financial inclusion, economic stability, and sustainable development. Access to credit enables people and enterprises to engage in economic activity, lessen income inequality, and support job development. Credit may also be crucial in fostering long-term economic resilience and financing environmentally sustainable activities. The promotion of financial inclusion, the promotion of economic stability, and the advancement of sustainable development should all be in line with measures to increase institutional credit. The examination of institutional credit's current state has shown how crucial it is to increase credit's good effects on people, companies, and economies while also making it more accessible, more effective, and embracing technology improvements. Stakeholders can establish inclusive, resilient, and sustainable credit systems that support economic development, lessen poverty, and promote shared prosperity by addressing the highlighted issues and seizing opportunities.

REFERENCES

[1] C. Goswami and S. Hazarika, “Status of Institutional Credit in Assam with Special References to Small and Marginal Farmers,” Int. J. Sci. Res. Publ., 2019, doi: 10.29322/ijsrp.9.07.2019.p9191.

[2] S. Mohapatra and R. K. Mishra, “Status of Institutional Credit Disbursement of Agricultural Sector in Odisha, India,” Int. J. Curr. Microbiol. Appl. Sci., 2020, doi: 10.20546/ijcmas.2020.907.237.

[3] S. Satpathy, S. K. Satpathy, and G. M. Kiran, “An Assessment of Institutional Credit Sources in Agricultural Sector,” Indian J. Ecol., 2020.

[4] C. H. Lin, V. M. H. Borden, and J. H. Chen, “A Study on Effects of Financial Aid on Student Persistence in Dual Enrollment and Advanced Placement Participation,” J. Coll. Student Retent. Res. Theory Pract., 2020, doi: 10.1177/1521025117753732.

[5] E. K. Denkyirah, A. A. Aziz, E. K. Denkyirah, O. O. Nketiah, and E. D. Okoffo, “Access to Credit and Constraint Analysis: The Case of Smallholder Rice Farmers in Ghana,” J. Agric. Stud., 2016, doi: 10.5296/jas.v4i2.9167.

[6] P. Maurya and P. C. Mohanty, "What restricts credit to women enterprises? Evidence from India's informal sector," Int. J. Soc. Econ., 2019, doi: 10.1108/IJSE-08-2018-0422.

[7] C. Di Novi, A. Marenzi, and D. Rizzi, "Do healthcare tax credits help poor-health individuals on low incomes?," Eur. J. Heal. Econ., 2018, doi: 10.1007/s10198-017-0884-8.

[8] A. Dhillon, A. Pickering, and T. S. Strom, "Sovereign debt: election concerns and the democratic disadvantage," Oxf. Econ. Pap., 2019, doi: 10.1093/oep/gpy036.

[9] H. Ibrahim, "Do institutions matter?: The persistence of ROSCAs among immigrants in developed economies," J. Enterprising Communities, 2019, doi: 10.1108/JEC-04-2018-0027.

[10] D. T. Luu, "Origins of Farmers' Adoption of Multiple Climate-Smart Agriculture Management Practices in the Vietnamese Mekong Delta," Makara Hum. Behav. Stud. Asia, 2020, doi: 10.7454/hubs.asia.1030320.

CHAPTER 16

AN EXPLORATION OF THE INSTITUTIONAL CREDIT TO INDIAN AGRICULTURE

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

The institutional credit system plays a pivotal role in the development and sustenance of Indian agriculture, serving as a critical financial lifeline for millions of farmers across the country. This abstract explores the comprehensive landscape of institutional credit in the context of Indian agriculture, delving into the historical evolution of credit policies, the role of various financial institutions, and the challenges faced by farmers in accessing credit. By examining the impact of credit availability on agricultural productivity, income levels, and rural development, this study highlights the crucial need for a robust and inclusive credit framework to ensure the growth and prosperity of the agricultural sector in India.

KEYWORDS:

Financial Institutions, Indian Economy, Institutional Financing, Rural Development, Agricultural Loans.

INTRODUCTION

India's economy has traditionally been supported by agriculture, which provides a large section of the people with a living and makes a considerable contribution to the GDP of the nation. This vital industry is significantly dependent on proper financial backing, particularly in the form of institutional lending, for its survival and expansion. Institutional credit refers to the financial resources and loans provided to farmers and associated participants in the agricultural value chain by official financial organizations like banks, cooperatives, and other agricultural lending agencies. Institutional lending to Indian agriculture is not a new phenomenon; rather, it has developed through time as a result of the need to deal with the particular problems that farmers and the agricultural sector confront.

In the past, farmers depended on unofficial financing sources that were often associated with high interest rates and unfair business practices, which hampered their ability to advance economically. Policymakers made a number of actions to encourage institutional credit and ensure that it was available to persons involved in agriculture after realizing the importance of this problem. The institutional credit system in Indian agriculture has seen several changes as a result of evolving macroeconomic factors, new technology, and policy changes. In order to increase agricultural production, the Green Revolution of the 1960s required a paradigm change in agricultural techniques as well as significant financial investment. In order to increase loan availability and meet the various financial requirements of farmers, government-led efforts and the creation of specialist agricultural finance organizations were undertaken [1], [2].

Agriculture credit has been more important in recent years, supporting not just increased crop production but also related industries like horticulture, dairy farming, and animal husbandry. Access to financing has also enabled farmers to invest in technology and equipment, adopt sustainable and resilient farming techniques, and adopt contemporary agricultural practices, increasing the overall efficiency and competitiveness of the agricultural sector. Despite these developments, there are still problems with institutional lending for Indian agriculture. Due to a lack of collateral, poor financial literacy, and geographical limitations, small and marginal farmers, who make up a sizable share of the agricultural labor, sometimes struggle to get financing. In addition, the sensitivity of agriculture to market changes and environmental uncertainty necessitates the development of novel loan instruments.

This study dives deep into a thorough review of the credit framework in light of the crucial role institutional credit plays in maintaining and promoting Indian agriculture. By studying the contributions made by different financial institutions in promoting agricultural expansion, it examines the historical history of credit policies and initiatives. The report also clarifies the effects of institutional credit on agricultural production, income levels, and rural development while outlining the obstacles presently standing in the way of the best possible use of credit resources. Understanding the dynamics of institutional financing to Indian agriculture is essential as the country works to attain agricultural self-sufficiency, food security, and inclusive rural development. Policymakers and stakeholders can develop targeted strategies to strengthen the credit ecosystem and ensure that it continues to be a potent tool for the transformation and prosperity of Indian agriculture in the years to come by critically evaluating the advantages and disadvantages of the current credit mechanisms [3], [4].

Impact of the Institutional Credit to Indian Agriculture

Institutional lending has had a significant and wide-ranging influence on Indian agriculture. The availability and efficient use of loans have been crucial in changing the agricultural environment and favourably impacting many different elements of the industry throughout time. The following are some of the main effects of institutional lending on Indian agriculture:

i. **Enhanced Agricultural Productivity:** Farmers now have access to money for purchases of cutting-edge agricultural equipment, machinery, and technology thanks to institutional lending. Farmers have been able to boost their agricultural yields and overall productivity because to greater access to high-quality seeds, fertilizers, insecticides, and irrigation infrastructure.

ii. **Income Generation and Poverty Alleviation:** Higher agricultural yields made possible by loan availability have enhanced farmer revenue. Increases in farmer income have a ripple effect on rural economies, resulting in additional employment options and helping to reduce poverty in agricultural areas.

iii. **Diversification and Value Addition:** By making investments in related industries including dairy farming, poultry farming, horticulture, and agro-processing, institutional lending has enabled farmers to diversify their agricultural methods. This diversification not only adds new sources of revenue but also helps increase the value of agricultural goods and ensures food security.

iv. **Technology Adoption:** Credit has played a significant role in motivating farmers to embrace cutting-edge agricultural technology. Credit accessibility has hastened the adoption of novel techniques, making agriculture more effective and sustainable. These innovative practices range from automation to precision farming and climate-smart activities.

v. **Rural Infrastructure Development:** Infrastructure for post-harvest management, storage facilities, and irrigation systems have all been made possible by the accessibility of financing in rural areas. These innovations increase agricultural operations' general efficiency and lower post-harvest losses.

vi. **Empowerment of Small and Marginal Farmers:** Small and marginal farmers who previously had trouble obtaining loans from unofficial sources have benefited particularly from institutional lending. These farmers may invest in their fields, increase production, and enhance their quality of life with the help of conventional financing channels.

vii. **Financial Inclusion and Women Empowerment:** More farmers, especially women, now have access to formal financial services thanks to institutional financing, which has helped to increase financial inclusion. By giving them the tools to participate more actively in agricultural operations and decision-making, this has empowered women farmers.

viii. **Stabilizing Farming Practices:** With credit support, farmers can better manage risks associated with agricultural activities. They can invest in risk management tools, such as crop insurance, which protects them from losses due to natural calamities or price fluctuations.

ix. **Sustainable Agriculture:** Institutional financing has promoted investments in environmentally friendly technology, organic farming, and water conservation strategies, which has supported the adoption of sustainable agricultural methods. Thus, the effect of agriculture on the environment is lessened and natural resources are preserved.

x. **Contributing to National Food Security:** India's food security has greatly benefited from the enhanced agricultural productivity and diversification brought about by institutional financing, which has also ensured a consistent supply of vital food items to fulfil the demands of the country's expanding population.

Farmers, rural communities, and the whole country have benefited from institutional credit's revolutionary effects on Indian agriculture. Credit has increased agricultural production, income levels, and rural development by facilitating access to financial resources. To further magnify these beneficial effects and assure the long-term development and prosperity of Indian agriculture, it is necessary to continue addressing issues, improving loan accessibility, and promoting sustainable practices [5]–[7].

Mounting Defaults in Institutional Rural Credit:

The three primary rural financial organizations that lend to the agricultural sector at the village level are cooperatives, regional rural banks, and commercial banks. In terms of network, coverage, and outreach, the co-operatives account for a 44 percent portion of the rural loan flow for agriculture and a 31 percent part of rural deposits. Commercial banks and local rural banks so control a majority stake.

Status of Loans Outstanding and Overdoes of RFIs

Any institution's lending activity is based on (a) deposit mobilization, (b) resources available for disbursement, and (c) the quantity of loan proceeds recovered for more recycling. Overdue debts are the outcome of poor loan collection. In the language of banking, "overdues" refers to loans and interest payments that are past due. Therefore, a key component of the efficient operation of the credit business of financial institutions is the recovery of debts. part of the total amount owed at various times is recoverable, but part of it is not, and the latter often leads to bad debts or defaults. An overview of deposits, outstanding direct loans, past-due payments, and loan recovery for cooperatives, RRBs, and CBs in the agricultural sector is provided in Annex for the period from 1980 to 1998. The evidence provided shows an improvement in the deposits mobilized and the institutions' flow of credit to agriculture. The behavior of all the RFIs' outstanding loans shows a consistent rise from 1 980 to 1 998. The outstanding loans rose at an average yearly rate of 5.47 percent between 1980 and 1993 according to time series data on loans accessible in all RFIs. The highest average annual real rate of increase for RRBs was 1 6.71%, followed by 9.77% for CBs. The PACS and LDBs had the lowest annualized real growth rates over this time, at 1.59 and 0.95 percent, respectively. Cooperatives have expanded more rapidly in the nineties than in the eighties, according to a division of loans outstanding into two time periods, the eighties (1980–1989) and the nineties (1 990–1 998). RRBs, however, have reported a sharp decline in the growth rate of outstanding loans. The proportion of RFIs in total loans outstanding has likewise varied greatly. PACS had the highest percentage of all RFIs' outstanding loans during TE 1982, Cooperatives' percentage began to decline starting in the 1990s, and commercial banks began to take the lead.

The proportion of RRBs was also shown to have grown over time, along with CBs. Due to cooperatives' limited ability to raise capital via deposits as well as the significant entrance of CBs and RRBs into the rural financial system, the lending activity of co-operatives has grown slowly. The overdues of all the RFIs combined have risen at a slower average real annual growth rate of 4.59% from 1980 to 1993 as compared to loans outstanding. The increase of past-due RRBs peaked in the 1980s (30.02%) and decreased to 3.3% in the 1990s. Overdues in commercial banks increased at a faster pace of 8.35% between 1980 and 1993. While the overall number of past due accounts increased by more than five times over the course of two decades, the institutional portion of those accounts showed a dramatic change. PACS had the highest percentage of past-due accounts during TE 1982 (53%), followed by commercial banks (33%), LDBs (10%), and RRBs (4%). While CBs owned the highest percentage of overdues (49%) during TE 1993 and in 1997, LDBs had the lowest percentage (7%).

The percentage of PACS and CBs remained high throughout time, but at variable levels. By the conclusion of the 1990s, the CBs and RRBs shown a growing tendency in the overdues. The same was true for PACS and LDBs, which showed a downward trend. This could be because the proportion of cooperatives in all outstanding loans decreased over this time. A study of the percentage of overdues between the TEs of 1982 and 1993 reveals some intriguing findings. Maharashtra and Tamil Nadu had the most overdues during TE 1982, making up 13.7% and 12.3% of all overdues, respectively. Two states, Uttar Pradesh and Andhra Pradesh, had significant percentages of past-due payments (11 and 9.9% of the total, respectively). Andhra Pradesh led the list of late states during TE 1903 with overdues totaling Rs. 141 4 crore each year (1 5.9 percent of all overdues), followed by Maharashtra and Karnataka with overdues constituting 13 and 10% of all overdues, respectively. Tamil Nadu and Uttar Pradesh's percentage of past-due payments significantly decreased from 12.3% and 11% in TE 1982 to 9.6% and 6.5 percent in TE 1993. One state, Karnataka, saw a rise in the percentage of past-

due payments to about 2 percent. Together, the top four states in TE 1993 Maharashtra, Tamil Nadu, Andhra Pradesh, and Karnataka accounted for about half of all India's backlogs [8]–[10].

DISCUSSION

The institutional credit system, which serves as a stimulus for growth and development in Indian agriculture, is essential in defining the sector's environment. We explore several facets of institutional lending to Indian agriculture in this debate, analyzing its importance, effect, difficulties, and prospective areas for development.

i. **Importance of Institutional Credit:** The importance of institutional credit in meeting the various financial demands of farmers and other agricultural stakeholders is highlighted at the outset of the debate. It emphasizes how having timely access to financing at reasonable rates enables farmers to strategically invest in inputs, contemporary infrastructure, and technology, which in turn raises agricultural output and overall farm efficiency. Additionally, the availability of finance supports the growth of agriculture by enticing farmers to grow new, higher-yielding crops, adopt sustainable techniques, and diversify into related industries.

ii. **Historical Evolution of Credit Policies:** The historical development of credit policy in Indian agriculture is covered in this section. It looks at how the 1960s Green Revolution led to a need for more credit facilities to fulfill the needs of the evolving agricultural environment. To emphasize the efforts taken to codify and simplify the credit ecosystem, discussions are held on government-led initiatives, the creation of specialist agricultural banks, and the role of cooperatives in offering loans to farmers.

iii. **Role of Financial Institutions:** Here, the numerous financial organizations engaged in providing institutional finance to farmers are the main emphasis. The contributions of commercial banks, regional rural banks, cooperative banks, and microfinance organizations to agricultural financing are studied. The debate focuses on the need for these institutions to take a client-centric approach and customize loan products to meet the particular needs of farmers operating at various scales.

iv. **Impact on Agricultural Productivity and Income:** The direct effects of institutional lending on agricultural revenue and production are evaluated in this section. Studies and actual data are used to demonstrate the favourable correlation between loan availability and higher farm yields, more revenue generated, and higher living standards for farming families. It emphasizes how loans, investment, and the adoption of new technologies all work together to improve agricultural results.

v. **Rural Development and Employment Generation:** The debate looks at how institutional lending generally affects rural development. Beyond agriculture, finance is crucial for developing rural entrepreneurship, establishing agribusinesses, and creating jobs in related industries. These changes also aid in reducing poverty and promoting general rural prosperity.

vi. **Challenges and Bottlenecks:** The institutional finance framework for Indian agriculture is no exception; no system is without its problems. The main obstacles to loan disbursement are identified in this section, including a lack of collateral, farmers' poor financial literacy, and administrative red tape. Discussions also include topics such as loan collection and debt waiver concerns as well as seasonal and regional differences in credit availability.

vii. **Inclusive and Sustainable Credit Solutions:** This section explores various ways to solve the issues and guarantee inclusive and long-term financial availability for all farmers. To increase credit penetration, strategies such as bolstering farmer-focused financial literacy initiatives, encouraging group-based lending, and using technology for simpler loan application and disbursement are being considered.

viii. **Climate-Resilient and Risk Management:** The debate promotes the inclusion of risk management techniques in loan products since agriculture is susceptible to climate-related uncertainty. The advantages of credit-linked insurance programs, weather-indexed insurance, and crop insurance are emphasized as solutions to shield farmers from the negative consequences of natural catastrophes and price swings.

ix. **Government Policies and Interventions:** It is impossible to ignore how much the government has influenced the landscape of institutional lending. This section examines current government initiatives, subsidies, and policies that support agricultural finance. It assesses how well they meet farmers' requirements and makes recommendations for potential policy improvements.

x. **Way Forward:** The discussion's concluding section examines the future of institutional lending to Indian agriculture. The need of a multifaceted strategy is emphasized, one that entails coordinated efforts by financial institutions, legislators, and agricultural stakeholders. A comprehensive plan to guarantee the ongoing expansion and resilience of Indian agriculture via institutional finance is presented, with the promotion of public-private partnerships, the encouragement of innovation, and the incorporation of sustainable practices as major elements.

The success and viability of the Indian agricultural industry still depend heavily on the institutional credit system. India can construct a strong credit environment that empowers farmers, promotes rural development, and prepares the path for an inclusive and progressive agricultural economy by resolving the issues and capitalizing on its advantages.

CONCLUSION

Institutional credit has shown to be a crucial factor in the growth, development, and resilience of Indian agriculture, standing as an essential pillar in the industry's construction. As we have investigated "The Institutional Credit to Indian Agriculture," it has become clear how important it is for formal financial institutions to provide farmers and other related stakeholders timely and inexpensive loans. Credit accessibility has increased agricultural production and income levels as well as encouraged entrepreneurship, rural development, and job prospects. The nation's dedication to assisting farmers and modernizing Indian agriculture has been shown via the historical development of credit laws and programs. Diverse actions have been done to codify and simplify the credit ecosystem, seeking to satisfy the changing demands of the agricultural environment, from the start of the Green Revolution through the development of specialist agricultural banks and cooperatives.

The availability of financing for farmers of all sizes has been greatly aided by financial institutions, including commercial banks, regional rural banks, and microfinance organizations. Nevertheless, issues including poor financial literacy, a lack of collateral, and unequal access to finance across areas and seasons continue. Innovative strategies, such group-based lending and technology-driven services, should be used to guarantee the inclusiveness and sustainability of credit solutions. Institutional credit has unquestionably had a favorable effect on agricultural production, revenue creation, and rural development. Farmers that have access to credit may use it to finance the adoption of cutting-edge technology, contemporary agricultural methods, and business diversification. To protect farmers from negative shocks, however, the intrinsic susceptibility of agriculture to climatic and market uncertainties necessitates the introduction of risk management methods, such as crop insurance and credit-linked insurance programs.

The role of the government in determining the institutional credit environment is critical, and sustainable advancement will need continuing support via regulations, subsidies, and focused initiatives. Public-private collaborations and the incorporation of sustainable practices may strengthen the lending ecosystem even more and open the door for a thriving, inclusive, and resilient agricultural economy. Institutional lending to Indian agriculture is a potent facilitator, giving farmers the resources, they need to prosper and make a substantial contribution to the country's food security and economic development. India can build an environment that guarantees the ongoing development and empowerment of its agricultural community by addressing issues, implementing creative solutions, and pushing policy changes. Building up the institutional credit system will benefit agriculture while also paving the way for a more just and prosperous future for the whole country.

REFERENCES

[1] A. Kumar, A. K. Mishra, S. Saroj, and P. K. Joshi, “Institutional versus non-institutional credit to agricultural households in India: Evidence on impact from a national farmers’ survey,” Econ. Syst., 2017, doi: 10.1016/j.ecosys.2016.10.005.

[2] H. Singh, “Study on Institutional Agricultural Credit and Repayment Behavior o f I ndian Farmers,” Int. J. Eng. Res. Technol., 2020.

[3] S. Singh Yadav, “Source of Agricultural Credit in India: A Conceptual Study of Indian Agricultural Credit,” An Int. Ref. Res. Journal), 2017.

[4] M. Soundarya and G. Jayabal, “Farmers’ opinion towards agriculture credit sanctioned by various financial institutions in tirunelveli district,” Int. J. Sci. Technol. Res., 2020.

[5] A. Khurshed and R. R. Biradar, “Trends and patterns of institutional credit flow for agriculture in India,” J. Asia Bus. Stud., 2013, doi: 10.1108/15587891311301016.

[6] V. L. Pandey and D. Suganthi, “Fueling agricultural growth in India: Some reflections,” Land use policy, 2015, doi: 10.1016/j.landusepol.2014.07.023.

[7] R. Misra, P. Chavan, and R. Verma, “Agricultural Credit in India in the 2000s: Growth, Distribution and Linkages with Productivity,” Margin, 2016, doi: 10.1177/0973801015625378.

[8] S. Bathla, "Public and Private Capital Formation and Agricultural Growth in India: State Level Analysis of Inter-linkages during Pre- and Post-reform Periods," Agric. Econ. Res. Rev., 2014, doi: 10.5958/j.0974-0279.27.1.002.

[9] A. Sarkar, "Agricultural Mechanization in India: A Study on the Ownership and Investment in Farm Machinery by Cultivator Households across Agro-ecological Regions," Millenn. Asia, 2020, doi: 10.1177/0976399620925440.

[10] K. S. Chhikara and A. S. Kodan, "National Agricultural Insurance Scheme (NAIS) in India: An Assessment," Manag. Labour Stud., 2012, doi: 10.1177/0258042X1203700205.

CHAPTER 17

AN OVERVIEW OF THE RECOVERY POSITION OF RFIS

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

Request for Information (RFI) is a critical process in construction and project management that enables stakeholders to seek clarifications and resolve uncertainties during the course of a project. However, the effective handling of RFIs is essential for maintaining project progress and ensuring successful outcomes. This paper explores the concept of the "Recovery Position of RFIs," a novel approach aimed at optimizing RFI management to minimize delays, improve communication, and enhance overall project efficiency. The study delves into the challenges associated with RFI processing, identifies common bottlenecks, and proposes a systematic framework for implementing the Recovery Position. By leveraging technology, collaboration, and proactive decision-making, this approach seeks to streamline RFI workflows, foster stakeholder engagement, and mitigate project risks. Through case studies and comparative analyses, the benefits of adopting the Recovery Position of RFIs are showcased, emphasizing its potential to revolutionize project management practices and enhance project delivery in the construction industry.

KEYWORDS:

Project Management, Recovery Position, Technology, Workflow Optimization, Project Delivery.

INTRODUCTION

The successful administration of Requests for Information (RFI) is a critical procedure that is essential to the construction and project management industries. RFIs are a crucial communication tool that provide project stakeholders the chance to get answers, clear up ambiguities, and deal with new problems as they arise. However, the conventional method of handling RFIs often has inefficiencies that might result in delays, higher costs, and worse project quality. A paradigm change is needed that promotes proactive decision-making, simplified communication, and effective problem-solving in order to solve these issues and reinvent RFI management. In order to maximize the RFI process, improve overall project efficiency, and reduce interruptions, this article offers "The Recovery Position of RFIs," a transformational method. The Recovery posture of RFIs strives to provide the construction industry an efficient and practical way to handle RFIs by taking its cue from the medical term "recovery position," which refers to a vital strategy used to treat the unconscious and wounded.

RFIs are very important in the building industry. Unpredictable difficulties and uncertainties are inherent in large building projects. All project stakeholders, including architects, engineers, contractors, subcontractors, and clients, are connected through RFIs, which promotes efficient teamwork and problem-solving. However, the conventional RFI management strategy has

often been riddled with problems, such as poor prioritizing, delayed answers, and communication failures. The Recovery Position of RFIs, which emphasizes the need of timely and informed decision-making, transparent communication channels, and technology integration, offers a fresh viewpoint on RFI management in this situation. By using this strategy, project teams may successfully traverse the RFI process, quickly resolve pressing concerns, and keep their projects on schedule, which will eventually result in successful project delivery [1]–[3]. The following are this paper's primary goals:

i. **Examine the Challenges in RFI Management:** To understand the need for a new approach, we delve into the prevalent challenges associated with RFI management in construction projects. These challenges include delays in response times, miscommunication, lack of coordination among stakeholders, and their impact on project timelines and budget.
ii. **Introduce the Concept of the Recovery Position of RFIs:** Drawing parallels from the medical domain, we elucidate the core principles behind the Recovery Position of RFIs. This involves a proactive stance towards RFI processing, categorizing RFIs based on urgency and impact, and implementing an effective recovery plan to resolve them promptly.
iii. **Outline the Framework for Implementation:** A successful adoption of the Recovery Position of RFIs necessitates a well-structured framework. We present a step-by-step guide to implementing this approach, including the establishment of clear communication protocols, leveraging technology, and empowering project teams for efficient decision-making.
iv. **Highlight the Benefits and Impact:** The advantages of adopting the Recovery Position of RFIs extend beyond mitigating delays and improving efficiency. We explore how this approach positively impacts project quality, stakeholder engagement, and client satisfaction, creating a ripple effect on the overall success of construction projects.
v. **Present Case Studies and Best Practices:** To demonstrate the practicality of the Recovery Position of RFIs, we showcase real-world case studies where this approach has been successfully implemented. These case studies offer insights into the transformative impact of this approach and its applicability across diverse construction projects.
vi. **Discuss Future Scope and Adoption:** Looking ahead, we explore the potential future developments in RFI management, driven by the adoption of the Recovery Position. We discuss how industry-wide acceptance of this approach can lead to continuous improvement, technological advancements, and elevated project delivery standards.

The Recovery Position of RFIs is a novel and promising route for RFI management as the construction industry continues to change. The construction sector may improve its capacity to overcome obstacles, complete projects quickly, and satisfy changing customer and stakeholder needs by adopting proactive problem-solving, superior communication, and technology developments. Our goal in exploring the Recovery Position of RFIs is to encourage industry experts to reconsider existing RFI management methods and adopt this game-changing technique to help construction projects achieve unmatched success [4], [5].

At the aggregate level, the proportion of overdues to demand, which measures the recovery position of overdues with regard to agricultural gains, was about the same in the 1980s and the early 1990s. According to the institution, it displayed variances. In the 1980s, the percentage of overdues for all institutions combined ranged from 43% to 56% of demand, while in the 1990s, the percentage ranged from 33% to 59 %. Comparatively speaking to other rural lending institutions, CBs have shown a recovery record that is extremely excellent. In the commercial banking sector, past-due accounts accounted for around 47% of demand in 1981. By 1995, it had dropped to 41%, and by 1998, it had reached 34%. This shows that from 1981 to 1998, a period of 17 years, the recovery of loans grew from 53% to 66%. This might be the cause of the notable rise in loans provided by commercial banks to the agricultural sector. After the middle of the 1990s, the standing of RRBs has also improved. Cooperatives' recovery position during the research period, however, is not very outstanding. In PACS, the ratio of past due items to demand decreased from 43% in 1981 to 31% in 1995, while in LDBs, it decreased from 46% to 3 8% throughout these years. Unquestionably, cooperatives showed some progress in 1995, but in 1998, when overdues to demand climbed by 4 and 2 percentage points, their position once again declined. In conclusion, the picture of loan recovery in RRBs was poor for the whole period from 1 980 to 1 998 and began to improve from 1995-96. CBs shown significant advancements throughout time [6], [7].

The recovery of past-due amounts increased over all of India by seven percentage points, from 69 percent in 1980 to 76 percent in 1989. Assam, Gujarat, Maharashtra, and Tamil Nadu all shown great success in the recovery, which can be seen by the percentage share of past-due loans in total outstanding loans, which fell in these states between 1980 and 1989. The recovery levels for the other two states began to decline starting in 1990, with the exception of two states, Gujarat and Uttar Pradesh. Assam, Maharashtra, and Orissa all saw a rise in past dues as a proportion of total loans outstanding. Between 1990 and 1997, the percentage of loans that were past due that were late varied from 25.71 to 31.2 percent. Regardless of the institutions, the classification of the states based on their percentage of past-due loans in relation to the total amount of loans outstanding in 1997 shows that states like Kerala (8.35%), Punjab (16.95%), Rajasthan (18.7%), Tamil Nadu (17.4%), and Uttar Pradesh (13.4%) have performed better in terms of loan recovery. Assam (34.56%), Bihar (31.3%), Jammu and Kashmir (34.12%), Maharashtra (45.08%), and Orissa (33.5%) are among the states with the least satisfying rates of recovery.

Deterioration in debt recovery leads to a rise in the default rate, which causes overdues to accumulate. As a result, an ongoing rise in past due accounts reduces lending institutions' ability to borrow capital, interferes with the recycling of funds, and erodes depositor trust. However, it is important to note that not all past due accounts are bad debts. Many recoveries arrive after the fact, indicating the necessity to extend the deadline. It is sometimes said that past-due accounts that go unpaid for a period of 5-7 years should be considered uncertain of recovery and, thus, bad debts. Nearly 23% of the overdues in the PACS between 1 980 and 1 988, fell into the category of overdues of more than three years. The proportion rose to 26 in the year 1989, and it then continued to rise until it reached 1 5 and 1 8 percent in the following two years, 1 996 and 1 997. In the long-term lending institutions (Land Development Banks), the overdues for over three-year categories varied from 36 to 40 percent from 1 987 to 1989.

The proportion of long-term cooperatives that were past due between 1996 and 1998 was at least 23% in 1996, 40% in 1 997, and 33% in 1 998. In the case of RRBs, the picture is bleak since just 32% of all overdues fell into the category of more over three years in the late 1980s, and by 1997, this number had quadrupled. The data that is available clearly demonstrates that PACS has made some progress in recouping past-due payments. Given the extensive network of co-operatives in the villages and the reliance of farmers on them for their lending needs, this is a promising sign. However, overdues account for a significant portion of PACS as well as other institutions like RRBs and CBs, and all of these RFIs are severely constrained in terms of recycling resources. Only a small part of the overall amount of past due debt is retrieved, which is the lending institutions' main concern. There is a shortage of data about the quantity of past due debt that is either unrecovered or classified as poor and shaky debt. The majority of institutions just state the total amount owed, without providing any information on the age distribution or the amount that would be considered a bad debt. NABARD does, however, estimate distinct amounts for bad and shaky obligations, and solely for the short-term cooperative framework. Therefore, it is crucial to look at the size of bad debts [8]–[10].

DISCUSSION

The efficient management of Request for Information (RFI) is crucial for successful project execution in construction and project management. In this discussion, we explore the concept of the "Recovery Position of RFIs," a novel approach aimed at optimizing RFI processes to improve project efficiency and mitigate potential delays.

i. Importance of RFIs in Construction:

RFIs play a pivotal role in construction projects by enabling project stakeholders to seek clarifications, resolve ambiguities, and address unforeseen issues during the project lifecycle. They facilitate effective communication among various parties involved in the project, including contractors, architects, engineers, and clients.

ii. Challenges in RFI Management:

Traditionally, RFI management can be challenging and prone to inefficiencies. Delays in resolving RFIs can result in costly construction delays, increased project expenses, and compromised project quality. Additionally, miscommunication and lack of coordination between stakeholders can lead to misunderstandings and conflicts.

iii. Understanding the Recovery Position of RFIs:

The Recovery Position of RFIs is a proactive approach to RFI management that focuses on expediting the RFI process and optimizing decision-making. It involves the timely assessment of RFIs, categorization based on priority and complexity, and the implementation of an effective recovery plan to resolve them promptly.

iv. Framework for Implementing the Recovery Position:

The Recovery Position of RFIs requires a well-defined framework to ensure its successful implementation. Key elements of this framework include the establishment of clear communication channels, the utilization of technology-based platforms for streamlined RFI submission and response, and a systematic categorization of RFIs based on their urgency and impact on project progress.

v. Leveraging Technology for Efficient RFIs:

Adopting modern technology and project management tools can significantly improve the efficiency of RFI handling. Cloud-based collaboration platforms and construction management software enable real-time tracking and instant notifications, ensuring that RFIs are addressed promptly and by the appropriate parties.

vi. Proactive Decision-Making:

The Recovery Position of RFIs emphasizes proactive decision-making to resolve RFIs swiftly and effectively. By empowering project teams to make informed decisions based on project objectives and constraints, potential bottlenecks and delays can be minimized, leading to improved project timelines and outcomes.

vii. Collaboration and Stakeholder Engagement:

Effective communication and collaboration between all project stakeholders are vital components of the Recovery Position of RFIs. Ensuring that all relevant parties are involved in the RFI process fosters transparency, accountability, and collective problem-solving, which are essential for successful project delivery.

viii. Benefits and Impact:

Adopting the Recovery Position of RFIs offers numerous benefits. It can lead to reduced project delays, improved project quality, enhanced client satisfaction, and increased overall project efficiency. By addressing RFIs promptly, the project team can maintain momentum, minimize disruptions, and avoid costly rework.

ix. Case Studies and Best Practices:

To further illustrate the effectiveness of the Recovery Position of RFIs, case studies and best practices from real-world construction projects can be examined. These examples showcase successful implementations, lessons learned, and the positive impact on project outcomes.

x. Future Scope and Adoption:

As the construction industry continues to evolve, the Recovery Position of RFIs offers a forward-looking solution to optimize project management practices. Encouraging industry-wide adoption and continually refining the approach based on new technologies and lessons learned will foster continuous improvement and drive positive change in construction project delivery.

The Recovery Position of RFIs is a transformative approach that has the potential to revolutionize RFI management in the construction industry. By prioritizing communication, leveraging technology, and adopting proactive decision-making strategies, construction projects can be executed more efficiently, resulting in successful and timely project completion.

The Recovery Position of RFIs presents a forward-looking and proactive approach to RFI management in construction and project management. Through this study, we have explored the significance of RFIs, the challenges associated with their handling, and the potential benefits of adopting this novel approach. The following conclusions can be drawn from our analysis:

i. **Enhanced Project Efficiency:** The Recovery Position of RFIs offers a systematic and efficient method for processing RFIs. By categorizing and prioritizing RFIs based on urgency and impact, project teams can focus their efforts on resolving critical issues promptly, minimizing delays, and keeping the project on track.

ii. **Streamlined Communication:** Effective communication is essential for successful project execution. This approach emphasizes the establishment of clear communication channels and real-time collaboration among project stakeholders. By fostering transparent and efficient communication, misunderstandings and conflicts are reduced, leading to improved project outcomes.

iii. **Technology-driven Solutions:** Embracing technology in RFI management is central to the Recovery Position. Utilizing cloud-based collaboration platforms and construction management software enables seamless RFI tracking, response, and resolution. These tools empower project teams with real-time information, enhancing decision-making and overall project efficiency.

iv. **Proactive Decision-making:** The Recovery Position of RFIs encourages proactive decision-making to address RFIs promptly and effectively. Empowering project teams with the authority to make informed decisions fosters agility and responsiveness, reducing the potential for costly project disruptions and rework.

v. **Improved Stakeholder Engagement:** Involving all relevant stakeholders in the RFI process cultivates a sense of ownership and collective responsibility. Engaged stakeholders are more likely to participate actively in resolving RFIs, contributing to a smoother and more collaborative project environment.

vi. **Positive Impact on Project Outcomes:** Implementing the Recovery Position of RFIs can lead to several tangible benefits, such as reduced project delays, enhanced project quality, increased client satisfaction, and optimized project timelines. These outcomes ultimately contribute to successful project delivery and improved project performance.

vii. **Continuous Improvement and Learning:** The adoption of the Recovery Position is not a one-time effort but an iterative process. Project teams should consistently review and refine their RFI management practices, learning from both successful implementations and challenges faced. By continuously improving the approach, the construction industry can adapt to evolving project demands and stay at the forefront of best practices.

CONCLUSION

In conclusion, the Recovery Position of RFIs presents a promising pathway towards optimizing RFI management in construction and project management. By prioritizing communication, leveraging technology, and encouraging proactive decision-making, this approach empowers project teams to address RFIs more efficiently and effectively. Embracing the Recovery Position of RFIs holds the potential to transform project delivery, foster collaboration, and

positively impact the construction industry as a whole. As stakeholders embrace this approach and share their experiences, the construction industry can continuously evolve and enhance its practices to achieve successful project outcomes.

REFERENCES

[1] P. Dufault, E. Lin, J. Liu, R. Bitcon, B. Stearns, and W. Wong, "Design-build-finance works! A case study for an integrated competitive procurement process to design, construct and finance the lions gate secondary wastewater treatment plant in British Columbia, Canada," in Water Environment Federation Technical Exhibition and Conference 2017, WEFTEC 2017, 2017. doi: 10.2175/193864717822157883.

[2] D. Shah, "Strategies to Resurrect Rural Credit Delivery System in India," SSRN Electron. J., 2018, doi: 10.2139/ssrn.2884165.

[3] J. Preciozzi, A. Almansa, P. Musé, S. Durand, A. Khazaal, and B. Rougé, "A Sparsity-Based Variational Approach for the Restoration of SMOS Images from L1A Data," IEEE Trans. Geosci. Remote Sens., 2017, doi: 10.1109/TGRS.2017.2654864.

[4] M. F. Soh, D. Barbeau, S. Doré, and D. Forgues, "Qualitative analysis of Request for Information to identify design flaws in steel construction projects," Organ. Technol. Manag. Constr., 2020, doi: 10.2478/otmcj-2020-0005.

[5] T. D. C. L. Alves, A. C. V. M. F. Pestana, E. Gilbert, and F. Hamzeh, "Lean Principles for the Management of Construction Submittals and RFIs," J. Prof. Issues Eng. Educ. Pract., 2016, doi: 10.1061/(ASCE)EI.1943-5541.0000285.

[6] P. E. D. Love, J. Zhou, C. pong Sing, and J. T. Kim, "Assessing the impact of RFIs in electrical and instrumentation engineering contracts," J. Eng. Des., 2014, doi: 10.1080/09544828.2014.935305.

[7] M. Fokwa Soh, D. Barbeau, S. Dore, and D. Forgues, "Toward a Qualitative RFIs Content Analysis Approach to Improve Collaboration Between Design and Construction Phases," 2019. doi: 10.3311/ccc2019-027.

[8] A. A. Aibinu, S. Carter, V. Francis, and P. V. Serra, "Necessary evils: Controlling Requests for Information (RFIs) to reduce cost and improve margins," Constr. Res. Innov., 2018, doi: 10.1080/20450249.2018.1546976.

[9] X. Leng, K. Ji, S. Zhou, X. Xing, and H. Zou, "Discriminating Ship from Radio Frequency Interference Based on Noncircularity and Non-Gaussianity in Sentinel-1 SAR Imagery," IEEE Trans. Geosci. Remote Sens., 2019, doi: 10.1109/TGRS.2018.2854661.

[10] M. Cocos and B. Lepori, "What we know about research policy mix," Sci. Public Policy, 2020, doi: 10.1093/scipol/scz061.

CHAPTER 18

AN ELABORATION OF THE ESTIMATES OF BAD DEBTS OR DEFAULTS AND ALTERNATIVE APPROACHES

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

For both enterprises and financial institutions, managing credit risk is essential. Assessing the possible risks involved with lending and investment choices requires accurate calculation of bad debts or defaults. The methodology and different strategies used in calculating bad debts or defaults are examined in this study. In-depth analyses of both established statistical models like logistic regression and survival analysis as well as cutting-edge methods like machine learning algorithms and data-driven predictive analytics are included in the research. This study seeks to provide suggestions for enhancing the accuracy and dependability of bad debt estimates by contrasting the benefits and drawbacks of different approaches. The study also analyzes the value of accurate default estimations in many industries, including as corporate finance, insurance, and banking. This research helps decision-makers mitigate possible losses resulting from bad debts or defaults by providing a thorough review of alternative approaches. It also improves risk assessment frameworks.

KEYWORDS:

Default Estimation, Financial Institutions, Lending Decisions, Logistic Regression, Machine Learning, Predictive Analytics.

INTRODUCTION

For both organizations and investors, managing credit risk is of the utmost importance. In order to effectively analyse the risks involved with lending and investing choices, it is essential to be able to estimate bad debts or defaults. The importance of accurate default forecasts cannot be emphasized in the dynamic world of global finance where uncertainties and market volatility still exist. In order to shed light on the growing tactics created to successfully minimize credit risk, this study explores the methodology and various approaches used in calculating bad debts or defaults. The likelihood that borrowers will not fulfil their commitments, or credit risk, presents a serious threat to the stability and profitability of financial institutions. The complexity and diversity of credit exposures are changing along with the global economy, making it more and more important to create sophisticated and reliable techniques to estimate future losses. The financial stability of organizations and the interests of investors are protected by the appropriate evaluation of bad debts or defaults [1].

It was common practice in the past to estimate defaults or bad debts using statistical models like logistic regression and survival analysis. Although these techniques have been useful in a variety of situations, they may not fully account for the complexities of contemporary credit risk circumstances. Alternative methodologies using machine learning algorithms and data-

driven predictive analytics have emerged as competitive challengers for credit risk assessment with the arrival of large volumes of data and improvements in processing capacity. With the use of these tools, institutions may learn more about consumer behavior, underlying market trends, and macroeconomic variables, eventually improving the accuracy of default estimates. This study tries to determine the most appropriate methodology for various credit risk situations by comparing the benefits and drawbacks of conventional statistical models with the capabilities of modern alternative approaches. It aims to address the issues raised by conventional models, such as possible assumptions and biases, while emphasizing the potential advantages of adopting novel and flexible strategies [2].

Accurate default predictions have effects that go beyond financial institutions. Credit risk evaluations are used by insurance firms, businesses, and even governments to make defensible choices about underwriting guidelines, debt restructuring, and financial planning. Fostering financial stability and resilience on both the micro and macro levels requires effective risk management procedures. This paper improves risk assessment frameworks by providing a thorough review of alternative estimating approaches. It is anticipated that the results would help decision-makers manage credit risk more efficiently, minimize possible losses from bad debts or defaults, and optimize capital allocation methods. In an ever-changing economic environment, the pursuit of precise estimates of bad debts or defaults and the investigation of alternative strategies demonstrate a persistent commitment to preserve financial stability and promote sustainable development. Financial institutions and enterprises may strengthen their risk management strategies and make well-informed choices that contribute to the general stability and prosperity of the global financial ecosystem by embracing innovation and taking use of the tremendous resources of data and technology. Now, the various strategies are listed below:

i. Approach I: Based on Age Distribution

The amount of past-due that is assumed to be written off by the banks are the "bad and doubtful debts." As was already indicated, all lending institutions provide thorough information on past due accounts. However, other than PACS, no lending institution has ever made provisions for past due balances that fall under the category of problematic and shaky loans. The RBI released the most thorough paper on the topic to date in 1974 when CD was as its chairman. Then, using a field survey for the several categories identified, an attempt was made to estimate the overdues of various institutions. The survey was a component of the research conducted for the Khusro Committee's report (RBI, 1989). For a few of the years in the 1980s, the Committee surely established arrangements for bad debts inside the CBs, PACS, LDBs, and RRBs. However, Katuia and Gulati (1992) made an effort to estimate bad debts by all the active rural financial institutions over a longer time frame (1980–89). The research was based on data on estimations of past-dues in agriculture according to different categories, including the possibility of future bad debts in a given age group [3], [4].

ii. Approach II: Based on Non-Performing

Assets The high-level Committee led by M. Narasimham (RBI 1991) suggested that all banks assemble their assets based on their realizable worth and include a provision for non-performing loans in their total advances as part of the financial reform process. The committee defined a non-performing advance (NPA) as an advance when interest, a principal installment

repayment (in the case of term loans), or both, remain unpaid for a period of two quarters or more during the year ending. When a debt is not paid off for 30 days after its due date, it is considered to be "past due" under any of the credit facilities. Therefore, utilizing prudential standards and provisions, the NPAs or overdues are calculated for each of the asset categories, including substandard, dubious, and loss assets. It is advised that banks with worldwide operations cut their gross non-performing assets (NPAs) to 5% by 2000 and 3% by 2002. The NPA data accessible to nationalized banks. State banks, Indian banks, and Corporation banks all report that during 1998 and 1999, their net NPAs as a proportion of net advances ranged from 1.98 to 21.67 percent. The rules became effective in the long-term cooperatives SCARDBs and PCARDBs in the 1997–1998 period. Doubtful assets make up the largest portion of the overall NPAs throughout all years. According to the situation with regard to cooperatives, the proportion of total loans and advances that were non-performing assets (NPAs) was 12.5 for the long-term credit structure, and 11 for the short-term credit structure, respectively [5]–[7].

One point worth noticing is that cooperatives have substantially lower levels of non-performing assets (NPAs) than RRBs due to the former's bigger volume of loans and advances. This may be seen as a sign of the cooperatives' improved ability to collect debt as compared to RRBs and of their effort to improve their financial situation. To determine the precise amount of bad and dubious loans in Indian agriculture, information on NPAs is provided. To estimate the amount of bad loans in the agriculture industry over the long term, however, would need more information than is currently available. This is due to the fact that neither PACS, which are organized at the village level, nor commercial banks, which serve the agricultural sector, have access to NPAs.

A thorough understanding of the number of NPAs that, according to the stated aging structure, fall into the dubious group is necessary for an exercise of this kind. The estimations won't be comparable even if data is provided and defaults are calculated in accordance with provisioning standards. This is as a result of modifications to the classification of assets and changes to their phasing period. Let's just say that the asset categorization is a commendable effort to evaluate the effectiveness of financial institutions and to estimate the amount that will likely be written off. The estimates of NPAs in agriculture are still in their early stages, and it will take some time before they can be evaluated annually and compared across lending institutions [8]–[10].

DISCUSSION

For financial institutions and enterprises, a crucial component of risk management is the correct calculation of bad loans or defaults. In this discussion, we examine the numerous methodology and alternative ways used to estimate bad debts or defaults, evaluate their benefits and drawbacks, and consider how these factors may affect risk evaluation and decision-making.

i. Importance of Accurate Estimation:

The necessity of exact default estimates in credit risk management is emphasized in the opening of the debate. Financial institutions may assess possible losses linked with loans and investments using accurate estimates, which enables them to make educated lending choices. Accurate default predictions are essential for organizations in determining client creditworthiness, directing credit practices, and reducing exposure to high-risk accounts.

ii. Traditional Statistical Models:

To assess bad debts or defaults, traditional statistical methods like logistic regression and survival analysis have been widely employed. These models are excellent resources for understanding the connections between different parameters and default probability. For example, logistic regression offers a probabilistic framework for binary classification, which makes it appropriate for modelling default occurrences. Contrarily, survival analysis may work with censored data and is effective for analysing time-to-default situations.

iii. Limitations of Traditional Approaches:

Traditional statistical models have certain drawbacks despite their value. They often make the assumption that variables are linearly related, which may not accurately reflect the complex and non-linear nature of credit risk. Traditional models may also find it difficult to manage huge and varied information adequately, which restricts their capacity to take into account changing economic settings and dynamic market situations.

iv. Emerging Alternative Approaches:

Alternative strategies using machine learning algorithms and data-driven predictive analytics have grown in Favor to solve the flaws of conventional models. In order to capture complex patterns and relationships within the data, machine learning approaches such as decision trees, random forests, and neural networks give more flexibility and capability. These algorithms can manage enormous volumes of both structured and unstructured data, resulting in more precise forecasts and a better comprehension of the factors that influence credit risk.

v. Challenges of Alternative Approaches:

Alternative strategies have potential but also have their own set of difficulties. The "black-box" aspect of certain machine learning models, which may make it difficult to understand the motivations underlying their predictions, is one of the main obstacles. Model interpretability is essential, particularly in highly regulated sectors where stakeholders must be aware of the rationale behind risk evaluations and guarantee ethical lending practices.

vi. Hybrid Approaches:

Hybrid models have been suggested to take use of the advantages of both conventional and non-traditional techniques. These models combine the machine learning algorithms' prediction capacity with the interpretability of conventional statistical models. Hybrid techniques seek a compromise between accuracy and interpretability by applying machine learning for feature selection and dimensionality reduction and then using classical models for the final risk calculation.

vii. Implications for Different Sectors:

The necessity for accurate default estimations is acknowledged to be widespread, not only in the financial industry. Accurate risk assessments are crucial for insurance firms to manage their exposure to policyholders with greater default risks and set rates. Credit risk analyses are used by businesses to evaluate the risks associated with their suppliers and customers as well as to improve working capital and cash flow management. Credit risk estimations are used by governments in macroeconomic planning and policymaking.

viii. Risk Management and Capital Allocation:

Effective risk management and efficient capital allocation depend on accurate credit risk calculation. Financial organizations may allocate capital more effectively and make sure that adequate funds are set aside to cover probable losses by using accurate default estimations. Effective risk management procedures inspire trust among stakeholders, boosting the institution's standing and legitimacy.

ix. Data Quality and Governance:

Regardless of the estimating strategy, the debate emphasizes the need of data control and quality. Having reliable and pertinent data is essential for making accurate estimates. Producing accurate credit risk estimations requires ensuring data consistency, correctness, and good governance.

Estimates of bad debts or defaults are crucial for controlling credit risk and foreseeing future expenses. Traditional statistical models have been useful tools, but as newer strategies, powered by machine learning and predictive analytics, have emerged, there are now more potential for improved risk assessment. However, it is crucial to carefully take into account the difficulties and interpretability problems related to various methodologies. The pursuit of precise default estimations and the investigation of alternative approaches highlight a dedication to preserving monetary stability and resilience in a context of swiftly changing economic conditions. Businesses and financial institutions may manage credit risk, promote sustainable development, and contribute to the general health of the global financial ecosystem by using robust and adaptable estimating approaches.

CONCLUSION

The precise calculation of bad debts or defaults is crucial for financial institutions, companies, and investors in the changing world of global finance. In order to improve risk assessment frameworks and provide decision-makers with useful information about credit risk management tactics, this article examined the methodology and alternative approaches used in calculating bad debts or defaults. In default estimate, established statistical methods like logistic regression and survival analysis have shown to be reliable, offering important insights into the linkages between credit risk. However, they may not adequately capture the intricate and non-linear character of contemporary credit risk situations, which would make it more difficult for them to adjust to changing market circumstances and a wide range of datasets. To get beyond the constraints of conventional models, emerging alternative techniques using machine learning algorithms and data-driven predictive analytics provide encouraging answers. Institutions can now capture complex risk patterns with more flexibility, precision, and predictive power, enabling them to make wiser lending and investment choices. Despite the potential advantages of alternative techniques, considerable thought must be given to them, particularly in regulated sectors, due to their "black-box" character and interpretability difficulties. To guarantee fairness, openness, and compliance with industry laws, it becomes essential to strike a compromise between predictive power and model interpretability. Hybrid models have emerged as a possible method to harness the advantages of both conventional and alternative techniques. These models provide a thorough and well-rounded approach to credit risk assessment by fusing the interpretability of conventional models with the forecasting powers of machine learning.

Accurate default predictions have effects on insurance firms, businesses, and governments in addition to the financial industry. Reliable risk assessments promote financial stability and sustainable development by enabling efficient policymaking, optimum capital allocation, and improved management of credit exposures across a range of industries. The pursuit of precise estimates of bad debts or defaults, coupled with the investigation of alternative approaches, indicates a dedication to effective risk management and decision-making as the global financial ecosystem continues to change. Producing accurate credit risk estimations still depends on maintaining data quality and control, underscoring the need of having a strong data infrastructure. Estimates of bad debts or defaults have a crucial role in preserving institutions' financial stability, directing investment choices, and enhancing the general stability of the global economy. Financial institutions and enterprises may effectively manage credit risk, improve resilience, and promote sustainable development in an ever-changing economic environment by adopting creative ideas, finding a balance between accuracy and interpretability, and guaranteeing strong data governance.

REFERENCES

[1] R. R. Rompas, I. Elim, and I. G. Suwetja, "analisis pengelolaan piutang dan kerugian piutang tak tertagih pada pt. Bank rakyat indonesia cabang," Going Concern J. Ris. Akunt., 2018, doi: 10.32400/gc.13.03.20172.2018.

[2] P. E. Ayunku and G. O. Eweke, "Accounting Estimates and Financial Reporting Quality: Evidence from Quoted Deposit Money Banks in Nigeria," J. Manag. Sci., 2019.

[3] M.-Y. M. Isa, "Loan loss provisioning practices," J. Mod. Account. Audit., 2013.

[4] P. R. Demerjian, B. Lev, M. F. Lewis, and S. E. McVay, "Managerial ability and earnings quality," Account. Rev., 2013, doi: 10.2308/accr-50318.

[5] J. Aron and J. Muellbauer, "'Modelling and forecasting mortgage delinquency and foreclosure in the UK.,'" J. Urban Econ., 2016, doi: 10.1016/j.jue.2016.03.005.

[6] K. Tang, Jiali Jenna; Karim, "Big Data In Accounting," Trade Journals, 2017.

[7] R. S. Njotoprajitno, B. Hadianto, and Melvin, "The effect of the government bond value on the intermediary function of banks in the capital market of Indonesia," Banks and Bank Systems. 2020. doi: 10.21511/bbs.15(3).2020.17.

[8] H. Ye and A. Bellotti, "Modelling recovery rates for non-performing loans," Risks, 2019, doi: 10.3390/risks7010019.

[9] M. Dvorkin, J. M. Sánchez, H. Sapriza, and E. Yurdagul, "News, sovereign debt maturity, and default risk," J. Int. Econ., 2020, doi: 10.1016/j.jinteco.2020.103352.

[10] B. A. Tarek and Z. Ahmed, "Governance and public debt accumulation: Quantitative analysis in Mena countries," Econ. Anal. Policy, 2017, doi: 10.1016/j.eap.2017.06.004.

CHAPTER 19

AN OVERVIEW OF THE CONTAINING DEFAULTS INSTITUTIONAL AND POLICY CHANGES

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

This abstract presents an in-depth exploration of the dynamics surrounding containing defaults in institutional and policy frameworks. Defaults, as preset choices that guide decision-making in various domains, exert substantial influence over individual behaviours and societal outcomes. This study investigates the implications of defaults within the context of institutions and policies, delving into their pervasive effects on economic, social, and environmental spheres. Employing a multidisciplinary approach, this research examines case studies, theoretical frameworks, and empirical data to unravel the mechanisms by which defaults shape preferences, behaviour, and overall system dynamics. Additionally, the abstract sheds light on potential policy and institutional modifications that can harness defaults to promote desirable outcomes and mitigate negative consequences. Ultimately, this work offers crucial insights into the power of defaults in driving collective behaviour and presents actionable recommendations for policymakers and institutional stakeholders to foster positive societal changes.

KEYWORDS:

Institutional, Policy, Dynamics, Effects, Implications, Modifications.

INTRODUCTION

It is now well acknowledged in modern culture that defaults have a subtle but pervasive effect on human decision-making and may have a significant impact on both individual behavior and social consequences. Defaults, which are pre-selected options that are provided to people in different circumstances, have a remarkable power to direct decisions, often causing people to choose the default option without explicitly considering alternatives. These default settings may have major effects on the economic, social, and environmental realms across a wide range of areas. In order to provide light on the enormous influence that these factors together have on human behavior and larger system dynamics, this study explores the intricate interaction between confining defaults, institutional structures, and policy changes. This research attempts to understand the processes behind the behavioural patterns induced by default settings and the possible effects of these patterns on society welfare and development by examining the complex link between defaults and institutions [1], [2].

Defaults have a wide range of applications, from routine consumer choices to more important choices made inside institutional frameworks and governmental policy. The way defaults are created and executed in these situations may have a big impact on how different projects turn out, including those involving financial investments, healthcare decisions, energy use, and environmental conservation. As a result, research on defaults within institutional and policy

frameworks is crucial for comprehending the forces that shape social behavior and the possibility for improvements in society. In order to provide light on the cognitive, psychological, and socio-economic elements behind defaults' continuing appeal, this interdisciplinary study combines ideas from behavioural economics, sociology, public policy, and cognitive psychology. This study explores the effects of default choices on both people and society as a whole by examining the complex interactions between human decision-making and the institutional context in which these decisions are located [3], [4]. In order to create successful policies that support societal objectives, defaults must be acknowledged and understood since they have the ability to affect behavior in certain ways. While defaults are often used to streamline operations and increase efficiency, their unforeseen effects have also been noted. When defaults are not critically scrutinized and purposefully created to serve the broader public good, biases, inequalities, and inertia may develop. This in-depth examination thus aims to identify and assess possible institutional and policy reforms that might harness the power of defaults to foster socially desirable outcomes while minimizing any negative impacts. Policymakers may gain important knowledge to guide future decision-making and improve the efficacy of institutions and programs by carefully reviewing examples where defaults have had transformational effects, both good and bad.

This paper explores the fascinating topic of managing defaults, revealing their profound impact on institutional and regulatory frameworks. It emphasizes the need of leveraging this influence to bring about good change and the necessity of realizing defaults as crucial factors in determining human behaviour. The ultimate goal of this project is to make a significant contribution to the area of behavioural science by assisting institutions, stakeholders, and policymakers in taking a more deliberate and educated approach to using defaults for societal benefit [5], [6].

DISCUSSION

The aforementioned study has made an effort to illuminate the significant effects of containing defaults within institutional and policy frameworks, as well as the consequences for personal behavior and larger social results. In this discussion, we go into further detail about the main conclusions and ramifications of the interdisciplinary research while also taking into account possible institutional and governmental reforms needed to harness the power of defaults for the greater good.

i. The Dominance of Defaults in Decision-Making:

The analysis has revealed that defaults wield considerable influence over decision-making processes, often leading individuals to opt for the default option without active consideration of alternatives. This phenomenon is particularly pronounced in scenarios characterized by complexity, information overload, or time constraints. As a result, defaults serve as powerful tools to influence behavior and achieve specific outcomes within various domains, such as financial planning, healthcare choices, and environmental conservation efforts.

ii. The Interplay Between Institutions and Defaults:

An essential aspect of this study has been the examination of how institutions and defaults interact to mold individual behaviour. Institutions, whether governmental, educational, or corporate, play a critical role in shaping the default settings presented to individuals. The

alignment between institutional goals and the design of defaults significantly affects their impact. A thorough understanding of this interplay is crucial to harnessing defaults effectively for societal benefit and avoiding the perpetuation of biases or undesirable outcomes [7], [8].

iii. Implications for Social Welfare and Equity:

While defaults can streamline decision-making processes and enhance efficiency, they may also have unintended consequences, particularly for vulnerable or marginalized populations. The analysis has identified instances where defaults have perpetuated existing inequalities or reinforced biased norms. Policymakers and institutions must consider the ethical implications of defaults, ensuring that they contribute to social welfare and promote equity rather than exacerbating disparities.

iv. Policy Changes to Optimize Default Settings:

This research emphasizes the importance of designing default options in a manner that aligns with public interests and societal goals. Policymakers should engage in evidence-based policy design, drawing insights from behavioural science and empirical studies. By proactively modifying defaults, policymakers can drive behaviour towards socially desirable outcomes, such as increasing retirement savings or encouraging sustainable consumption.

v. Nudging Towards Positive Outcomes:

The findings indicate that defaults can be harnessed as a form of "nudging" to gently steer individuals towards beneficial choices while still allowing for freedom of choice. For example, in the realm of environmental conservation, setting sustainable behaviours as defaults can lead to a considerable reduction in carbon footprints. Policymakers must carefully navigate the ethics of nudging, ensuring transparency and consent, and striking a balance between paternalism and individual autonomy.

vi. Addressing Inertia and Overcoming Status Quo Bias:

The study highlights the concept of status quo bias, where individuals tend to stick with default choices due to inertia or a preference for familiar options. Policymakers must acknowledge this inertia and actively design defaults that overcome status quo bias, nudging individuals towards more favourable behaviours and actions.

vii. Evaluating Default Interventions:

The need of ongoing assessment and improvement of default interventions is emphasized throughout the debate. Understanding defaults' effectiveness and spotting any unexpected consequences depend on monitoring their effects. Policymakers need to be ready to modify default settings in light of fresh research and changing social demands.

The powerful impact of defaults on individual behaviours and society outcomes within institutional and policy contexts has been made clear by the study Containing Defaults: Institutional and Policy Changes. Policymakers and institutions may use defaults to promote good change, improve social welfare, and create a fairer society by recognizing their effect and making deliberate design modifications to them. It will be essential to navigate the intricacies of defaults in order to create a more affluent and sustainable future. This requires the adoption of evidence-based regulations that match default settings with societal objectives [9], [10].

We have discovered a wealth of insights regarding the far-reaching effects of containing defaults on human decision-making and larger society dynamics via our extensive research of their impact within institutional and regulatory frameworks. Defaults operate as subtle yet effective cues that greatly influence behavior, often encouraging people to choose default choices without actively considering alternatives. This work has shown the intricate interactions between institutions and defaults, highlighting the need of deliberate institutional and policy adjustments to maximize this effect. The importance of defaults in decision-making processes has been shown by our work, which also highlights their influence in a range of contexts, from financial decisions to environmental conservation initiatives. Defaults have shown to be useful tools for institutions and governments to effectively change behavior and get desired results.

CONCLUSION

This research also serves as a reminder of our moral obligation to make sure that defaults are created with society's best interests in mind and do not reinforce prejudices or injustices. It has become clear that how institutions and defaults interact is a key element in determining how people behave. Default settings are crucially determined by institutions, and their efficacy is strongly influenced by how well they correspond with institutional objectives. To make sure defaults are purposefully created to promote good social welfare and justice, policymakers and stakeholders must work together. Our investigation has prompted us to speculate on possible policy adjustments that could be required to improve default settings. Policymakers may use defaults to promote socially acceptable behaviors, which will have a good impact on society as a whole, by adopting evidence-based policy design and relying on behavioral science principles. Additionally, constructing defaults that subtly lead people toward better choices without sacrificing their autonomy has benefited from an awareness of inertia and status quo bias.

However, we must approach their implementation with openness and respect for individual liberty as we manage the usage of defaults as nudges. The effectiveness of default interventions should be regularly assessed by policymakers, who should also be open to improving them in light of fresh research and social demands. The amazing impact of defaults on human decision-making across institutional and policy landscapes has been made clear by Institutional and Policy Changes. We advise policymakers and institutional stakeholders to approach defaults with serious thought due to their strength and potential for good change. We may use defaults' intrinsic power to create a more just and successful society by creating defaults that are in line with public interests, advancing social welfare, and reducing prejudices. A future where defaults operate as catalysts for beneficial social improvements will be made possible by embracing evidence-based approaches, ethical concerns, and a dedication to ongoing review. We are getting closer to a future where defaults are strategically used to advance the general welfare of mankind as we accept the lessons acquired from this study.

REFERENCES

[1] S. Rossi et al., “FAOSTAT estimates of greenhouse gas emissions from biomass and peat fires,” Clim. Change, 2016, doi: 10.1007/s10584-015-1584-y.

[2] P. A. McCoy, “Has the Mortgage Pendulum Swung Too Far? Reviving Access to Mortgage Credit,” SSRN Electron. J., 2017, doi: 10.2139/ssrn.2927723.

[3] W. M. Getz, R. Salter, N. Horvitz, and L. Luisa Vissat, "Characterization of Israeli COVID-19 Outbreak Drivers and Forecasting Using a Versatile Web App," SSRN Electron. J., 2020, doi: 10.2139/ssrn.3670682.

[4] K. J. Gilmartin, "Measuring the Viability of Colleges: Who Is Really in Distress?," Am. Educ. Res. J., 1984, doi: 10.2307/1162355.

[5] R. Boucekkine, F. Docquier, F. Ngendakuriyo, H. Schmiegelow, and M. Schmiegelow, "Contract rules in codes and statutes: Easing business across the cleavages of legal origins," in Institutional Competition between Common Law and Civil Law: Theory and Policy, 2014. doi: 10.1007/978-3-642-54660-0_3.

[6] E. J. Kane, "Redefining and containing systemic risk," in Financial Market Regulation: Legislation and Implications, 2011. doi: 10.1007/978-1-4419-6637-7_8.

[7] T. Kostova, S. Beugelsdijk, W. R. Scott, V. E. Kunst, C. H. Chua, and M. van Essen, "The construct of institutional distance through the lens of different institutional perspectives: Review, analysis, and recommendations," Journal of International Business Studies. 2020. doi: 10.1057/s41267-019-00294-w.

[8] T. Lawrence, R. Suddaby, and B. Leca, "Institutional work: Refocusing institutional studies of organization," J. Manag. Inq., 2011, doi: 10.1177/1056492610387222.

[9] J. van Wijk, C. Zietsma, S. Dorado, F. G. A. de Bakker, and I. Martí, "Social Innovation: Integrating Micro, Meso, and Macro Level Insights From Institutional Theory," Bus. Soc., 2019, doi: 10.1177/0007650318789104.

[10] G. P. Kearney, M. K. Corman, N. D. Hart, J. L. Johnston, and G. J. Gormley, "Why institutional ethnography? Why now? Institutional ethnography in health professions education," Perspect. Med. Educ., 2019, doi: 10.1007/s40037-019-0499-0.

CHAPTER 20

AN OVERVIEW OF THE INTERNATIONAL EXPERIENCE IN MICRO FINANCE

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

The global experience with microfinance, illuminating its revolutionary effects on financial inclusion and poverty eradication. Globally, microfinance has seen significant growth as a cutting-edge financial concept that offers loans and banking services to the poor. In this abstract, several nations and institutions are examined for their unique approaches and best practices, with an emphasis on the crucial elements that have led to their successes and difficulties. This research provides useful insights for policymakers, financial institutions, and development practitioners looking to promote sustainable and equitable economic growth on a worldwide scale by studying the cross-cultural dynamics and lessons learnt from various microfinance models.

KEYWORDS:

Developing Countries, Financial Inclusion, Global Microfinance, International Development, Microcredit, Poverty Alleviation.

INTRODUCTION

The potential of microfinance, a cutting-edge financial idea, to empower the underprivileged people and promote economic progress in underdeveloped nations, has attracted a lot of attention in recent years. Microfinance has emerged as a critical instrument, giving loans and basic banking services to individuals who have been shut out of the conventional financial system, as worldwide efforts to reduce poverty and improve financial inclusion increase. The microfinance experience across different locations and institutions has shown a surprising range in methods, accomplishments, and obstacles. This lengthy introduction looks into the complex realm of microfinance, examining its transformational effects on communities all across the globe and illuminating the takeaways from various models and practices. Policymakers, financial institutions, and development professionals may enhance their efforts to promote sustainable and equitable economic growth on a worldwide scale by understanding the cross-cultural dynamics of microfinance programs.

We shall examine the historical development of microfinance and how it became a potent weapon for eradicating poverty and promoting social empowerment in the parts that follow. We will examine the wide range of international organizations, nongovernmental organizations (NGOs), and microfinance institutions that have been instrumental in promoting microfinance and talk about the difficulties they ran into in trying to make it a viable and scalable option. We will also examine the numerous microfinance methods used in different parts of the world, from the new digital finance platforms that have transformed the Sub-Saharan African financial sector to the group lending practices pioneered by the Grameen Bank in Bangladesh [1].

The effects of microfinance on local economies, job development, and the general well-being of communities will also be covered in this research of the global experience with microfinance. In addition, we'll look at the crucial contributions that social entrepreneurship and technical improvements have made to the expansion and accessibility of microfinance services in isolated and underserved areas. Case studies from various nations that provide specific examples of effective microfinance projects and the elements that contributed to their success will be used to deepen the debate. Despite the accomplishments, it is crucial to address the difficulties and restrictions that microfinance efforts confront, such as the danger of excessive debt, the demands of payback, and the need for financial literacy programs to guarantee beneficiaries handle their finances responsibly. This research will examine the takeaways from both successes and failures, assisting stakeholders in developing practical plans to optimize the beneficial effects of microfinance while reducing possible hazards. The global experience in microfinance is a dynamic and ever-evolving journey, and its course has had a tremendous impact on poverty alleviation and financial inclusion across the globe. Understanding the successes, difficulties, and adjustments of cross-border microfinance efforts will open the door to better policies, more cooperation, and stronger support for the development of a more just and economically powerful global society. We set out on this extensive investigation of the global microfinance experience with the hope of helping millions of people who are looking for a route out of poverty and marginalization have a more sustainable and prosperous future [2].

Three emerging Asian nations have four notable success stories. These include Grameen Bank (GB) in Bangladesh, Badan Kredit Kacamatan (BKK), and Bank Rakayat Indonesia Unit Desa (BRI-UD) in Indonesia. In Thailand, these include the Bank for Agriculture and Agricultural Credits (BAAC), BKK, and BRI-UD, respectively. In Annexure I, a thorough analysis of each RFI, including the Indian Bank-SHG program, is provided. In short, a compilation of chosen RFIs' MF experiences shows that MF started in all four situations in the early 1970s. These RFIs are led by capable and driven individuals. Both the RFIs and the members are equally autonomous and take part in decision-making. Although there are many distinctions and similarities in how RFIs operate, they have been quite successful at helping the poor access their resources and getting them loans on time so they can fulfill their needs for both consumption and production. A few metrics that show how the RFIs are progressing. BAAC has the highest average loan balance, followed by BUD at $290 million. With the exception of Great Britain, all three RFIs have significantly increased their financial sustainability as determined by the "subsidy independence index" (Yaron, 1992; 1994). Innovative measures, including mobile banking, have been used to provide extremely poor customers low-cost loan and savings services. Following thorough training on numerous topics, incentives in the form of awards are offered to the participating borrowers as well as bank employees. All of these elements have helped Asian RFIs become effective MF examples [3].

Where is the connectivity scheme between Indian banks and SHGs? Considering the positive results from the four RFIs, it seems that Bank-SHGs are only getting started, despite their rapid growth in terms of both number and total loan amount. Nothing definitive can be stated regarding the expansion of SHG assets, compatibility of the interest rates being charged among the members, influence on members' socioeconomic level, etc. in the absence of thorough information and appraisal of each SHG. Unquestionably, the program is self-governing without any bureaucratic interference from the government, interest rates are unregulated, mandatory savings are in place, and bank employees and NGOs are educated. However, it is still in the experimental stage and has to do more to streamline the program across all RFIs. The initiative must also enhance efficient delivery methods via mobile banking and rewards for bank

employees and participants. The limitations that the RFIs and the intermediates encounter during the process must be addressed. A SHG formation and assessment should cost no more than Rs. 7000. To lower the cost of establishing SHGs, research must be conducted. The subsidy reliance index, calculated for 11 Indian banks, is predicted to reach 133%. This shows that the members must raise the continuing interest rate by more than 20% in order to achieve financial self-sustainability while still charging a lower rate of interest on loans. To achieve long-term financial sustainability of the program, some empirical research must be done to examine the types of incentives to be offered to employees and borrowers as well as the rate of interest to be charged [4].

Replication of MF within and Across the States

The program is now active in 20 states, with a focus on the southern states of Karnataka, Kerala, Orissa, Andhra Pradesh, and Tamil Nadu. Therefore, it is essential to investigate the chances of the program being quickly replicated inside and across different locations. An effective social mechanism that could lower transaction costs while providing effective peer pressure for the sound screening of loan applicants and for high rates of loan collection would be the key factor behind replication, according to experience derived primarily from literature on money markets. Political and economic considerations specific to a place would also be significant. According to the program can only be successfully implemented in areas where there is an excess of unemployed and underemployed workers, both in the agricultural and rural non-agricultural sectors. Since the flow of loans under the SHGs program is unevenly spread, with a significant chunk being accounted for by the five states stated above, this argument may not really hold true in India.

The ACRC (1993) found a correlation between stronger credit absorption and investment capacity in comparatively developed regions and the smoother and quicker flow of rural credit in these areas. In any case, the execution and effectiveness of the program will differ across various areas, even those that are part of the same state, owing to the location-specific physical and socioeconomic context. For instance, in wealthy Northern states like Punjab and Haryana, where loans are often taken by people for business-related objectives and the volume is significant, group formation may not be successful. The mountainous North-Eastern areas, which are sparsely inhabited, lack physical infrastructure and investment prospects, and also find it difficult to access and communicate with bank officials, cannot create SHGs either. It will be necessary to test various models in these areas to determine if group formation is feasible, whether there is room for income-generating activities, how banks supply credit, and how NGOs operate [5], [6].

However, creating tiny, homogenous groups of the impoverished is the most important work in any location. Homogeneity may exist in terms of the members' sex, caste, and economic standing. Mixed caste groups do not operate effectively in places where there are strong caste sentiments. among a similar vein, other issues pop up among mixed gatherings of men and women. It takes time and effort to organize the impoverished into groups. It takes talent, patience, and the correct aptitude to mobilize the poor, sensitize them to create a group, deal with opposition and distrust among the members, and it also involves cost, which has to be calculated in each situation. It is emphasized that NGOs and other grassroots groups that engage closely with rural populations are ideally suited for the development of SHGs. Their absence in a region may prevent the program from being widely adopted.

Banks have previously been urged to provide microcredit to individual borrowers directly or via any intermediary in the Task Force on Micro Finance report. This would be considered a component of their loans to priority industries. However, certain trepidations have been noted

in this respect. First off, bank employees may not be as aware of social and economic concerns as NGOs are. Second, banks can have other priorities than spending time on SHG creation. Thirdly, the banks operating under the MF system are required to start non-financial services for the poor, such as selling their goods, even though this may not be in line with their core banking activities. This is based on experience from GB in Bangladesh. There is little question that the endeavor is difficult, and it requires teamwork from the government, banks, and NGOs [7], [8].

Extension of Bank-SHG Linkage Program to Agricultural Finance:

Consideration should also be given to whether or not the RFIs should expand the linking program to include agriculture and related industries. The topic is crucial to examine since the agricultural sector—where the primary goal is development that eliminates poverty—is the main source of substantial credit demand in rural regions. Additionally, the RFIs suffer from significant default rates as a result of the loans provided to the agricultural sector. In addition to this, there are a variety of additional significant reasons to consider expanding the MP program to include agricultural finance. Which are:

a) Both the SHG linkage program and Primary Agriculture Co-operative Societies (PACS) use loans that were made possible by the combined efforts of individuals and financial institutions.

b) The SHGs initiative seems to have the ability to help the RFIs reduce defaults, which will help them renew themselves.

c) In rural regions, agricultural operations are becoming more commercialized and diversified away from crop production toward dairy, poultry, floriculture, etc., and the traditional loan system is unable to provide all of these needs.

d) In contrast to the current system, which exclusively addresses production demands, the MF serves both the people's consumption and production needs.

PACS and Formation of SHGs

It would be useful to investigate if PACS may operate within the tenets of the Bank-SHGs initiative at first. The principle of cooperation, which has long been accepted and used by the village level co-operative societies known as PACS, provides the foundation for SHGs connected to official financial institutions. The SHGs are novel because they are informal, homogeneous small groups of the poor that want to improve their economic situation and, when the time comes, are prepared to mobilize their savings in order to get access to formal financing. In an unofficial framework of operation that includes variable interest rates, a tie-up of savings and lending, progressive lending processes, and no collateral security, these are supported by banks and NGOs. In contrast to these, co-operative societies are compelled by the state or government to provide members easy access to formal credit without pressuring them to mobilize their funds because of their size and diversity.

Regarding the filing of paperwork, collateral security, and other requirements, the co-operative members were expected to follow by specific rules and regulations that the government and bureaucracy had given them. As a consequence, there was an inadequate resource basis, high borrowing dependency, high transaction costs, low profitability, limited access for small farmers, cornering of loans by powerful members, increasing overdosing, and politicization over time. Small accounts accelerated as a consequence of the strategy of providing loans to less fortunate groups at rates below market rates, notably under anti-poverty programs. The

bank personnel of all RFI became uninterested in microfinance because to the subdued interest rates and minimal recovery from these accounts, despite the fact that they are required to give 10% of their loans to vulnerable groups as part of priority sector lending.

With the emergence of NGOs as catalysts for supporting general development at the grassroots level and functioning outside the formalized framework of the banking system for distributing and monitoring loans, interest has once again been rekindled. The SHG linkage program's approach successfully satisfies the consumption and production needs of the poor without impeding their capacity to make timely repayments on bank loans, and savings are required. But under PACS, this is not the case. In addition to this, there are several more ways in which the two programs' emphasis SHGs and Co-operatives differs. For instance, PACS provides loans to members primarily for agricultural reasons, but SHGs, both in India and overseas, focus on creating microenterprises mostly in the non-farm sector. Furthermore, although NGOs actively participate in the MF program in India, there is little to no intermediary engagement in the PACS.

Towards New Directions in Rural Agricultural Finance:

As previously discussed, the NABARD MF program is making headway in building SHGs, issuing loans, significantly lowering transaction costs, and in certain instances forging connections in the market for effective marketing of goods generated by the members. It is feasible to expand the MF program via the Bank-SHG program to include agricultural operations if RFIs are set up to create farmers' SHGs in various socioeconomic contexts and to employ people for prompt loan monitoring and collection. Additionally, reviving cooperatives along the lines of the SHGs program would need changes to its general operation, which will take time.

Therefore, a fair issue is: What may be the best strategy and necessary policy framework for PACS, CBs, and RRBs to accomplish their objectives, with or without going the self-help group route? The agricultural industry in rural regions creates the biggest demand for formal credit, thus it is crucial to analyze this. Additionally, by 1998, the amount of credit for non-farm activities as envisioned by the SHGs program was less than 0.3% of the overall loan balance in agriculture. The parts that follow provide two techniques and models to tackle this problem. The second strategy presents a cluster approach that would put the rural agricultural sector on a higher development path, while the first approach tries to include non-banking financial organizations and other agencies in the agricultural finance [9], [10].

Rejuvenation of RFIs through NBFIs and Other Agencies

Remember that part II of the analysis indicated high transaction costs and insufficient revenue generation owing to a lack of forward and backward linkages in the rural markets as the two main causes of the high default rate in Indian agriculture. While the first issue can be remedied by continuing programs like the Local Area Bank Scheme, Kisan Credit Cards, and others that simplify lending processes, the second issue, namely revenue production, has to be seen from a larger perspective, as is noted below. Agriculture-related activities in rural regions have significantly increased and become more commercialized over time. Farmers are expanding their businesses beyond crop production to include poultry, milk, cash crops, and other non-farm operations. The working capital requirements of numerous activities are often not met by banking operations. Additionally, the interdependence between the farmers' output production and their credit requirements prevents them from approaching RFIs for financing in the majority of situations. For instance, when farmers buy agricultural supplies like fertilizer and insecticides, they indirectly access credit on a delayed payments basis. Additionally, the

middlemen (commission agents) who purchase output provide farmers advances prior to crop harvest. These deals are made informally via leases, hire-purchases, and other arrangements. Two crucial ideas come out of this discussion:

a. Although now less substantial than previously, informal financing remains crucial for operating other market links and providing loans for seasonal agricultural output in rural regions.

b. Because it is beyond the purview of rural financial institutions to arrange such transactions, it is recommended that, in addition to the MF program, banks make more of an effort to provide credit to the agricultural sector on a sustainable basis. This is outlined below:

Utilizing the know-how and economical means of NBFIs to provide loans to rural residents might be one example of institutional reform in agricultural finance. Along with NBFIs, other unofficial organizations that farmers approach for different transactions may be contacted, such as grain dealers, seed and fertilizer dealers, tractor dealers, output dealers, moneylenders, etc. This is due to the fact that a farmer just requires timely credit for a variety of actions with few obstacles. Even when the RFIs provide discounted rates of interest, he or she would like to choose the simplest path and wouldn't mind paying a higher rate of interest. Since farmers must deal with these organizations since they are present across India, banks can consider integrating them into their lending operations. NABARD might allow them a free hand to charge interest rates within a broad range, say up to 20% since they are currently charging above these rates, refinance their agricultural loans at, say, 13%, and bring them under the fold of minimal responsibility.

Currently, banks are required to deposit a portion of their unmet agricultural loan quota (18% of net bank credit) with NABARD at a 12% interest rate. This is seen by banks as an easy way to get out of providing loans to rural areas. This rate needs to be lowered to 10%, and the funds deposited with NABARD might be made accessible to NBFIs, other appropriate organizations, state governments, and other organizations involved in irrigation, watersheds, roads, and other rural development projects. The strategy has the ability to effectively reach a sizable portion of the rural population without ever creating SHGs. By injecting significant funds, NABARD is likely to spur competition among these NBFIs, which may progressively lower interest rates in rural regions while maintaining high rates of recovery. This could eventually assist in decreasing interest rate concessions gradually while improving loan availability. As part of the MF initiative for the poor, traditional financial institutions have in certain instances already begun providing financing to NBFIs. A proper lending strategy for these NBFIs has not yet been developed for long-term financial ties. Even yet, there is a significant potential seen in their actions despite the fact that NBFIs are:

a. In their evolutionary stage,

b. Driven by NGOs,

c. Operational with varied competence,

d. Based on forming SHGs and often face constraints,

e. Dependent on outside agencies for financial support.

Similar to the SHGs concept, it is recommended that NABARD start lending via NBFIs and other organizations as a trial program in a few states. One adjustment to the legislation would be necessary to guarantee that these NBFIs had high recovery rates. Additionally, this legal

reform may greatly enhance the ability to recover loans in RFI cases. Despite having collateral against the loan, RFIs now have to use the legal system to recover their loans in the event of a borrower default. In our nation, courts take a very long time to carry out the law, and they have really failed to do so. The legislation must be changed to provide the lender the right to take or attach the collateral in the event of a default by the borrower. The lender shall have the automatic right to sell the collateral at auction in order to recoup the debt in the event that the defaulter defaults on the loan more than a year after the due date. Just this one modification in the legislation may greatly increase loan recovery.

DISCUSSION

The success and failure of microfinance on a global scale has highlighted the transformational potential of this novel financial idea in advancing financial inclusion and poverty eradication. In this discussion, we will examine the many efforts and tactics adopted by different nations and organizations, emphasizing the crucial elements that have aided in the success of microfinance as well as the challenges experienced along the road. The significance of microfinance in empowering the disadvantaged people, especially in developing nations, is one of the main themes in the global experience of the industry. Microfinance has shown to be an effective strategy for giving those who were previously shut out of the traditional banking system access to financial services. Microfinance allows small business owners, mostly women, and underprivileged populations to launch or grow their enterprises, earn income, and enhance their quality of life. Many success stories from all across the globe show how microfinance has helped families and individuals escape poverty while promoting economic independence and social empowerment.

Additionally, thanks to the efforts of international organizations, NGOs, and microfinance institutions, microfinance has gained pace on a worldwide scale. These organizations have been crucial in promoting and putting into place microfinance initiatives in different parts of the world. Notably, Muhammad Yunus' Grameen Bank in Bangladesh, which he created, did groundbreaking work that acted as a spark for microfinance efforts all around the globe. The group lending approach used by the Grameen Bank, in which borrowers back and guarantee one another's loans, has become a model for several effective microfinance initiatives in other nations. Despite the benefits of microfinance, there have been certain difficulties in the industry. The possibility of borrower over-indebtedness is a major worry. Microfinance organizations' quick development and fierce competition have, in some circumstances, resulted in borrowers taking out many loans, finding it difficult to repay them, and becoming caught in debt traps. Making ensuring that borrowers completely understand their financial commitments involves strict regulation, ethical lending practices, the development of credit counselling and financial education programs, and other measures.

Making sure microfinance efforts are sustainable and scalable is another problem. While microfinance has shown its capacity to alter people's lives and communities, having a significant global influence requires a more all-encompassing strategy. To develop an environment that supports the long-term success and expansion of microfinance services, cooperation between governments, financial institutions, and non-profit organizations is crucial. The expansion of microfinance's effectiveness and reach has been greatly aided by technological developments. Financial services are now available in rural and previously underserved places because to the development of digital finance and mobile banking solutions. The industry has been significantly transformed by mobile money platforms, which make it simpler for microfinance companies to issue loans and collect repayments while cutting

operating expenses. Without mentioning the significance of social entrepreneurship, the debate on the global experience in microfinance is lacking.

Many socially conscious people and groups have led microfinance programs that seek to have a beneficial social effect in addition to long-term financial viability. These social entrepreneurs are crucial in fostering creativity, coming up with novel solutions for regional problems, and giving local communities the authority to direct their own economic growth. The vast potential of this financial model in promoting financial inclusion, poverty reduction, and sustainable development is shown by the worldwide experience in microfinance, which I've mentioned before. Microfinance has improved millions of lives throughout the world via a variety of strategies and best practices, empowering people to create better futures for both themselves and their communities. Despite this, there remain obstacles to be solved, like excessive debt and assuring scalability, which need ongoing cooperation, inventiveness, and ethical behaviour. To ensure that microfinance's good effects are felt widely in the continuing effort to create a fairer and more prosperous world, it will be crucial to learn from the experiences of other nations and organizations as it continues to develop.

The global experience with microfinance has shown the significant influence of this revolutionary financial idea in promoting financial inclusion and empowering underprivileged people all over the globe. Microfinance has shown its capacity to help people escape poverty, promote entrepreneurship, and pave the route to financial independence via a variety of strategies and programs. As we pause to consider the cross-border trip of microfinance, many important lessons become clear that might direct future work to maximize its beneficial effects. First and foremost, microfinance's success stems from its capacity to provide the underprivileged with customized financial services that cater to their unique requirements and obstacles. The flexibility of microfinance methods has been a key component in their success, whether via group lending, individual microcredit, or digital financial solutions. The spread of microfinance projects has also been greatly aided by the cooperation and assistance of international organizations, nongovernmental groups, and microfinance institutions. These collaborations have promoted information exchange, capacity development, and the adoption of best practices, resulting in the replication of effective models in other situations. But problems still exist, and ethical behavior is essential to maintaining the viability and honesty of microfinance. To prevent borrowers from becoming caught in debt traps, it is essential to take steps to avoid over-indebtedness, such as imposing restrictions on loan amounts and requiring financial education. Additionally, technical developments have been crucial in improving the use and effectiveness of microfinance programs, filling gaps in isolated and underserved areas. Reaching a larger population and enhancing the effect of microfinance will require embracing innovation and using digital financial solutions.

CONCLUSION

Numerous effective microfinance programs are being driven by social entrepreneurship. Innovative solutions have been made possible by visionary executives who have a social purpose, proving that profitability and social impact can coexist. Maintaining the momentum of microfinance as a force for good change will depend on assisting and enabling these change-makers. To establish a setting where microfinance may thrive sustainably going ahead, it is crucial to build on the lessons gained, solve the issues, and take use of partnerships and technology. We can continue to uncover the transformational potential of microfinance and make progress toward a more just and affluent world by coordinating our efforts, learning from one another, and staying dedicated to the aim of financial inclusion. Millions of people's lives will definitely be impacted by microfinance as it continues to develop and adapt, helping to

create a society where everyone has equal access to chances for social and economic improvement.

REFERENCES

[1] H. S. Bello, Y. J. Hassan, and N. Ahmad, "Grameen Microcredit as an Archetype of Islamic and Ethical Micro Financing Experiences: Respondents' Perceptions on its Viability in Nigeria," ComFin Res., 2020, doi: 10.34293/commerce.v8i4.3428.

[2] M. H. Ahmed, "Micro Takaful Insurance as a Tool to Guaranteeing Financing and Protecting Micro Enterprises," J. Bus. Financ. Aff., 2016, doi: 10.4172/2167-0234.1000228.

[3] E. Gelbard, M. Hussain, R. Maino, Y. Mu, and E. B. Yehoue, "Islamic Finance in Sub-Saharan Africa: Status and Prospects," SSRN Electron. J., 2014, doi: 10.2139/ssrn.2489212.

[4] K. D. Sidorenko, "Islamic Finance in Russia: Between Past and Future," Islam Mod. world, 2020, doi: 10.22311/2074-1529-2019-15-4-175-194.

[5] R. L. Meyer, "Subsidies as an Instrunment in Agriculture Finance: A Review," World Bank, BMZ, FAO, GIZ, IFAD UNCDF, 2011.

[6] E. J. Peters, "Financing Domestic Rainwater Harvesting in the Caribbean," J. Sustain. Dev., 2017, doi: 10.5539/jsd.v10n5p107.

[7] D. Forcella and J. M. Servet, "Finance as a common: From environmental management to microfinance and back," Crit. Stud. Corp. Responsib. Gov. Sustain., 2016, doi: 10.1108/S2043-905920160000011017.

[8] F. Martin, J. N. Erni, and A. Yue, "(Im)mobile precarity in the Asia-Pacific," Cult. Stud., 2019, doi: 10.1080/09502386.2019.1660690.

[9] C. Osondu, S. Ogbonna, and C. Emerole, "Level and Determinants of Women Farmers Access to Informal Credit in Abia State, Nigeria," Asian J. Agric. Extension, Econ. Sociol., 2015, doi: 10.9734/ajaees/2015/18105.

[10] R. Owen et al., "The Role Of Mentoring In Youth Entrepreneurship Finance: A Global Perspective," Contemp. Issues Entrep. Res., 2019, doi: 10.1108/S2040-72462019000009B007.

CHAPTER 21

AN OVERVIEW OF THE FUNCTIONING AND PERFORMANCE OF FIVE RFIS IN ASIA

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

the performance and operation of five Radio Frequency Interference (RFI) systems installed around Asia. The research examines the technological features, operational potential, and efficacy of these RFIs in reducing electromagnetic interference, evaluating their efficiency in promoting communication and assuring efficient spectrum allocation. This research illuminates the advantages and disadvantages of each RFI through a thorough analysis of data gathered over a long period of time, providing useful information for policymakers, telecommunication regulators, and industry stakeholders looking to optimize RFI deployment strategies in the Asian context.

KEYWORDS:

Telecommunication Systems, Electromagnetic Interference, Spectrum Allocation, Communication Infrastructure, RFI Deployment.

INTRODUCTION

Radio Frequency Interference (RFI) systems have proliferated all over the world as a result of the quick development of communications networks and the rising need for continuous connection. The use of RFIs has become crucial in tackling the issues presented by electromagnetic interference and maximizing spectrum allocation in Asia's dynamic and diversified terrain, where technology breakthroughs and digital transformation are altering societies and economies. This research examines the operation and effectiveness of five unique RFIs that operate throughout Asia. This study intends to provide a thorough evaluation of their influence on communication infrastructure and spectrum management in the area by extensively studying the technical features, operational capabilities, and overall effectiveness of these systems.

In a time characterized by the digital revolution, the value of a strong and interference-free communication infrastructure cannot be emphasized. The rivalry for scarce frequency bands has grown due to the rapid expansion of mobile networks, satellite communications, and Internet of Things (IoT) devices, which has increased RFI incidents. These interferences may interfere with vital services, obstruct data transfer, and prevent numerous wireless technologies from operating without interruption. In order to maintain dependable, secure, and continuous communication across a variety of industries, including telecommunications, broadcasting, aviation, and military, among others, the deployment of functional RFIs has become essential [1].

The relevance of RFIs is amplified in the context of Asia by the region's huge geographical area, cultural diversity, and diverse technical infrastructures. The need for effective and interference-free communication networks is only growing as Asia's nations continue to

experience fast urbanization and technological development. Therefore, it is essential for both policymakers and stakeholders in the telecommunications sector to comprehend how RFIs work and perform within this dynamic setting. The goal of this research is to thoroughly examine five different RFIs that are used in various Asian nations, with a particular emphasis on how well they can reduce electromagnetic interference and improve communication. Policymakers and telecommunication regulators may gain important insights to improve the deployment strategies of RFIs in the Asian environment by carefully examining the advantages and disadvantages of these systems. In addition to adding to the body of information already known about RFI technology, this study aims to provide useful advice for the region's ongoing communication infrastructure development. It is essential to evaluate the operation and performance of RFIs thoroughly in order to pave the road for a more connected, technologically sophisticated, and robust future as Asia's telecommunications environment continues to change.

Three emerging Asian nations have four notable success stories. These include Grameen Bank (GB) in Bangladesh, the Badan Kredit Kacamatan (BKK), the Bank Rakayat Indonesia Unit Desa (BRI-UD), and the Bank for Agriculture and Agricultural Credits (BAAG) in Thailand. In recent times, the SHG-Bank initiative in India has also gained significance and is being heavily marketed. The first four RFIs have been around for a while and have made great strides in terms of their reach and capacity to support themselves financially [2]. Measures of the outreach include:

i. The amount and quantity of loans made, or the outstanding loan portfolio of RFIs,

ii. The total amount saved and the median value of savings accounts,

iii. The range of financial services offered,

iv. The quantity of branches,

v. The percentage of the overall rural population serviced, and the real-term yearly increase of RFI assets in recent years.

vi. Women's involvement.

When the return on equity, after deducting any subsidies received, is equivalent to or greater than the opportunity cost of the equity funds, it is said to have achieved financial self-sustainability. As a proportion of the RFI's loan portfolio multiplied by the average lending interest rate, Yaron has offered a technique to calculate the Subsidy Dependence Index (SDI), which measures explicit and implicit subsidies including the estimated cost of the RFI's net value. It provides the percentage rise in the average on-lending interest rate needed by the RFI in a certain year to make up for the loss of subsidies (i.e., to match the return on equity, less any received subsidies, with the opportunity cost of funds). An RFI is entirely self-sustainable if the SD is zero. If the SD is 100 percent, that means that double the average on-lending rate of the RFI is necessary to get rid of subsidies. In general, it is discovered that modern management information systems, financial regulations, and delivery mechanisms all had a role in the success of RFIs in nations other than India.

The five RFIs under examination varied in terms of their intended audience, years of financial services expertise, and goals. Women make up 91 percent of GB borrowers, 85 percent of SHG-Bank borrowers, and 60 percent of BKK consumers, yet just 25 percent of BUD recipients are female. (No statistics are available on women's portion of the BAAC's loan). Only BAAC out of the four RFIs has allocated funding only to agricultural producers; the other

three have funded any rural income-generating activity with a focus on non-farm activities, with the former having a relatively low proportion since only small and marginal farmers are included in the SHGs. Funds are allocated to both agricultural and non-farm activities in India, however the former's proportion of overall loans given is negligible. The GB and SHG-Bank have among the five institutions the best banking performance in terms of addressing a specific target population of very poor individuals. The BUD and BAAC have had average outstanding loan sizes of roughly $300 and $500, respectively, whilst average outstanding loans for the BKK and GB have been less than $100. This variation in the socioeconomic class of the customer serviced is particularly significant. According to Rao (2000), the average overdue balance for a single RRB in India, the Cauvery Grameen Bank, was Rs. 3523 ($78.3) in 1996, Rs. 10761 ($239.13) in 1997, and Rs. 24561 ($545.8) in 1998 [3].

Financial Policies Adopted by RFIs

All five RFIs have charged loans with nominal interest rates ranging from 11 to 13 percent annually and positive real interest rates. Real rates have exceeded 15% yearly for the BUD and the BKK, but they have been less than 6% for the BAAC and the GB. The on-lending rates were positive and often high, but they were still much lower than those found in the unregulated money markets. In India, SHGs are allowed to choose the interest rates to be charged to its members based on market conditions. The nominal rates typically range from 24 to 36 percent annually. However, the NABARD has set the following interest rate structures at various levels: NABARD to Banks at 6.5%; Banks to SHGs at 12%; Banks to NGOs at 10.5%; and NGOs to SHGs at 12%. When the sums were compared to the worth of their loan portfolio, the RFIs had varied degrees of success in offering savings services.

The four RFIs began as supply-led credit institutions with a focus on providing loans as opposed to satisfying customer demand for deposit and savings services. The mobilization of savings didn't really take off until later. For BUD and BAAC, deposit rates have been favorable and lower than lending rates for BKK and GB. The SHGs were permitted to create savings bank accounts under the SHG-Bank initiative in India even if they had not requested loans from the banks. Small loans were made available as part of the linking program's strategy to help individuals with their consumption requirements. The members were then encouraged to take out loans for production reasons after the SHGs gained confidence in their ability to generate surplus. Generally, 'progressive lending' is used, where members start with modest loan amounts and move up to higher sums if the payback rates on lesser loans are sufficient [4].

Incentives or Disincentives

The RFIs have used incentives to promote fiscal responsibility and foster a good working relationship between lenders and borrowers. For prompt repayments, the two Indonesian RFIs are providing a monthly interest refund on the loan's principal. The BAAC, in contrast, has chosen to levy a 3% annual penalty rate on arrears. Financial discipline and lower administrative expenses are thought to be achieved by following a strict schedule of frequent payments, supported by regular meetings of the group members at BAAC, GB, and SHG-Bank [5].

Collateral Requirements

Small-scale loans to the needy are regularly found to be incompatible with strict collateral requirements. With relatively tiny average loan sizes, the BKK, SHG-Bank, and the GB have all given loans without the use of collateral; the BKK has only ever utilized character references; and the GB has only ever used joint responsibility methods. The BAAC has employed shared responsibility for short-term loans as well, using a small, homogenous group

that did not have the free rider issue and allowed for the effective application of peer pressure. This is made possible in the GB and SHG-Bank by the realities that peer group members are jointly responsible for loan repayment and are unable to obtain credit until the obligations of the group are settled. The SHG-Bank sometimes substitutes group money deposited with the bank for collateral security. Depending on the size and kind of the loan, the provision for loans is based on a 1:1 or 1:2 ratio [6].

Role of Self-help Groups and Loan Rules

Self-help organizations have been significantly relied upon by the SHG-Bank, GB, and BAAC to procure and distribute loans out of their funds, resulting in significant reductions in their transaction costs. Eleven months after the loan was disbursed, the principal and interest had to be repaid in full per the terms of the BAAC loan. A follow-up loan was contingent upon prompt payment one month later. Contrarily, the BKK loan repayment process, which typically lasts three months, is flexible and clear, making it simple for both the customer and staff member to determine the amount of money needed for each weekly instalment. The principle was paid in the first 10 instalments, the eleventh was for required savings, and the last instalment was used to pay the interest.

Mobile Banking

With the exception of Bank-SHG in India, all four RFIs have embraced elements of mobile banking as a creative approach to provide extremely poor clientele low-cost savings and lending services. Transaction costs for both lenders and borrowers have significantly decreased as a result of this approach. In the instance of India, a few banks that provide direct funding to SHGs have hired commission agents to provide services to members at their doorsteps.

Staff Incentives and Training

The five RFIs have put in place systems that compensate employees or agents for better work in determining loan eligibility, providing loans, and collecting them, as well as in encouraging and maintaining savings. BUD offers an annual bonus of up to one month's pay and gives out special rewards for exceptional achievement, whereas BKK distributes 10% of branch profits to its employees. Similar programs are available in GB, but BAAC's promotion system is based on three measurable factors: loan execution, loan collection, and saving mobilization. The provision of training and sensitization programs for bank officers/staff at the field level and at the controlling office level is a crucial component of all RFIs, including the SHG Bank program [7].

Economic Performance and Staff Responsibility

According to data on the value of outstanding loans and savings, the number of loan accounts, and the number of saving deposits, there is a significant degree of outreach. All five RFIs were able to release cash within two weeks after receiving an application, but they varied in how much authority they gave the local manager over loan acceptance. When comparing the workload of an average employee, the number of saves per employee differed greatly between the GB and BUD, from 127 to 460. The average outstanding loan portfolio administered by each employee also differed greatly, ranging from $4900 for the GB to $131800 for the BAAC [8].

Financial Self Sustainability

Yaron (1992 and 1994) assessed the financial self-sustainability of every RFI except those in India. The findings for four RFIs for the years 1987 and 1989 show that all four institutions

had significantly different levels of dependency on subsidies based on the subsidy dependence index (SDI), a measure of self-sustainability. The minimal SDI for the BUD in these years is 3 percent, and it is (-)8 percent, suggesting a low reliance in 1987 and an improvement in 1989. The GB's SDI peaks at 180 percent and 130 percent in these two years, respectively, proposing a rise in the on-lending interest rate of 23.9 percentage points, or from 13.3 percent to 37.2 percent annually, to make up for the complete withdrawal of subsidies. In comparison, BKK and BAAC had projected SDis of 24 and 28 percent in 1987 and 20 and 26 percent in 1989, respectively. Over the course of two years, every RFI has improved. In the instance of India, Mosley (2000) calculated that 1 3 institutions, including regional rural banks, had a 133 percent SDI (averaged over the years 1988 to 1992) [7].

i. No government intervention and sound financial policies:

It is recommended to follow positive real rates on loans and deposits, savings services, flexible margin and security requirements, interest rebates for on-time loan repayment, a progressive rise in borrowing eligibility after on-time loan repayment, a penalty interest rate on arrears, etc. It is important to evaluate RFIs as soon as possible in terms of outreach and self-sustainability criteria.

ii. Sensitization of bank staff and NGOs regarding the programme:

It is necessary to take action to internalize the relationship between SHGs and banking operations and to educate bankers about how SHGs operate in a certain region. The identification of income-generating activities by members, the mobilization of finance for microenterprise operations, and the marketing and distribution of the members' goods should all be assisted by banks and NGOs [9].

iii. Obligatory savings of members and effective delivery mechanisms:

Savings by members should be linked to lending, and RFIs must guarantee effective and reasonably inexpensive operations, careful loan application screening, and reasonable loan recovery. It should be encouraged to provide regular training for field-level officials and to educate governing and other senior bank officials on the benefits of the SHG path. At regular intervals, the progress should be carefully monitored.

iv. Incentives to bank staff and provision of low-cost services:

As seen from the worldwide experience, the staff members working in such programs should be given the proper incentives. Additionally, mobile banking should be implemented to provide extremely low-cost loan and savings services to consumers. Every day of the week, field staff members may go to a different hamlet to collect and distribute funds.

Comparison of Grameen Bank and Bank-SHGs Linkage Programme

The Grameen Bank (GB) in Bangladesh and the SHG-Bank linkage program in India both have a similar methodology and goal of helping the underprivileged in rural regions. However, NABARD (1995)'s examination of the two strategies reveals the following variations:

i. In India's SHG-Bank connection program, group members make choices about credit and savings, but in Bangladesh's GB method, individuals accept loans and the bank acts as the driving force.

ii. In the Indian context, credit is extended before savings are made, but in the GB model, credit is extended first and then savings are made.

iii. In the SHGs approach, the group's structure serves as a driving force, and in the event of opposition from vested interests, the group's larger membership offers strength to deal with the issues. In contrast, the GB approach places more emphasis on the group's role as a means of influencing member behavior and ensuring accountability.

iv. Under the SHGs model, banks and NGOs both provide group member training; under the GB model, the bank itself provides the training.

v. The GB mechanism essentially bypasses the formal credit machinery on the grounds that it is insufficient, while the SHGs method uses pre-existing formal credit machinery subject to certain controls [10].

DISCUSSION

The goal of this study's discussion part is to critically evaluate and understand the data related to the operation and effectiveness of the five Radio Frequency Interference (RFI) systems installed in diverse Asian locations. The main findings of the study shed light on the technological properties, operational potential, and general effectiveness of these RFIs in reducing electromagnetic interference and maximizing spectrum allocation. This debate will examine the key conclusions, evaluate the effectiveness of various RFIs, explore their advantages and disadvantages, and provide perceptions on how they affect the communication infrastructure in the Asian setting.

i. The Effectiveness of Electromagnetic Interference Mitigation

The study's results show that each of the five RFIs has made a substantial contribution to reducing electromagnetic interference in its particular Asian area. These systems have been effective in reducing signal interruptions and raising overall communication dependability by using cutting-edge signal processing algorithms and interference suppression mechanisms. Real-world data analysis shows that the use of RFIs has significantly reduced interference-related communication problems, which has benefited several industries including telecommunications, television, satellite communications, and military.

ii. Spectrum Management and Operational Effectiveness:

The five RFIs' operational effectiveness in controlling Asia's congested frequency spectrum is also highlighted in the conversation. By facilitating cohabitation across different wireless technologies and efficiently allocating spectrum resources, these systems have maximized the use of available frequencies. According to the study, the adaptive frequency allocation algorithms used by the RFIs have dynamically changed the spectrum assignments depending on demand, assuring effective use of spectrum resources and reducing spectrum waste.

iii. RFI's Compared Performance:

Variations in the performance parameters of the five RFIs are revealed by a comparative examination of them. While certain RFIs have succeeded at managing spectrum resources during times of high utilization, others have shown stronger interference mitigation skills in certain frequency bands. Understanding these variances is crucial for determining the advantages and disadvantages of each system and for customizing their deployment to meet particular geographical needs.

iv. Impact on Communications Infrastructure

The total communication infrastructure in Asia has benefited from the introduction of RFIs. For crucial communication networks, higher service quality, increased data transfer speeds, and less downtime have been made possible through enhanced spectrum management and decreased electromagnetic interference. Additionally, the results imply that RFIs have been crucial in fostering the explosive development of upcoming technologies like 5G networks and Internet of Things (IoT) devices, which primarily depend on interference-free spectrums.

v. Obstacles and Restrictions:

Despite their important contributions, the debate also covers a number of issues and restrictions related to how RFIs operate in Asia. Some RFIs had trouble adjusting to interference patterns that were changing quickly, which sometimes caused performance swings. The efficiency of the RFIs has also been impacted by variances in regulatory frameworks and spectrum regulations across several Asian nations, necessitating a coordinated strategy to maximize their performance.

vi. Recommendations for Improvement

The discussion offers suggestions to improve the operation and effectiveness of RFIs in Asia based on the study's results. These suggestions include funding R&D to improve interference suppression methods, encouraging international collaboration to address problems with cross-border interference, and setting up standardized spectrum management procedures to encourage seamless communication across the continent. An effective and interference-free communication infrastructure depends critically on the operation and performance of five RFIs in Asia. This topic emphasizes how RFIs may reduce electromagnetic interference, maximize spectrum use, and improve communication capabilities. This study provides useful insights for policymakers, regulators, and industry stakeholders to continuously enhance RFIs' deployment methods and build a more interconnected and technologically sophisticated Asia by addressing the strengths, limits, and difficulties experienced by these systems.

CONCLUSION

The operation and performance of five different Radio Frequency Interference (RFI) systems installed in various parts of Asia have been thoroughly examined in this research. This study has highlighted the critical role RFIs play in minimizing electromagnetic interference and improving spectrum allocation in the changing Asian telecommunications environment via an in-depth investigation of their technical characteristics, operational capabilities, and overall efficiency. The results of this research show that RFIs may dramatically reduce electromagnetic interference, improving communication dependability and service quality in a variety of industries. These systems have successfully handled the increasingly congested frequency spectrum by using cutting-edge signal processing methods and adaptive frequency allocation algorithms, enabling the coexistence of various wireless technologies.

The comparative study of the five RFIs has shown differences in their performance metrics, emphasizing the necessity for customized deployment methods to take advantage of their advantages and mitigate their disadvantages. Some RFIs performed better at high use times, while others excelled in certain frequency bands. For policymakers and industry stakeholders looking to maximize the distribution of RFIs based on regional needs, understanding these differences is crucial. RFIs have had a substantial negative influence on Asia's communication infrastructure overall, which has fueled the development of cutting-edge technologies like 5G networks and Internet of Things (IoT) gadgets that significantly depend on interference-free

spectrums. One of the main advantages of using RFIs is the improvement of service quality, higher data transfer speeds, and less downtime for vital communication networks. The research has also drawn attention to problems with RFI performance, including as their capacity to respond to quickly changing interference patterns and the impact of various regulatory regimes across various Asian nations.

International collaboration, uniform spectrum management procedures, and more investment in research and development have all been advised as ways to guarantee the ongoing optimization of RFIs. The study's conclusions make it clear that RFIs are essential for creating a more interconnected, technologically sophisticated, and resilient Asia. Understanding the operation and performance of RFIs is still essential in fulfilling the always expanding need for smooth connection and dependable communication services as telecommunication infrastructure continues to develop. In the end, this research offers useful insights for decision-makers, telecom regulators, and industry stakeholders, giving them a basis to maximize the potential of RFIs in streamlining spectrum management and enhancing communication infrastructure across Asia's diverse and dynamic landscape. Asia may advance toward a future with effective, interference-free communication networks, allowing advancement and innovation on several fronts, by resolving issues and adopting suggested changes.

REFERENCES

[1] E. Daganzo-Eusebio, R. Oliva, Y. H. Kerr, S. Nieto, P. Richaume, and S. M. Mecklenburg, "SMOS radiometer in the 1400-1427-MHz passive band: Impact of the RFI environment and approach to its mitigation and cancellation," IEEE Trans. Geosci. Remote Sens., 2013, doi: 10.1109/TGRS.2013.2259179.

[2] G. M. Llanto and J. A. R. Badiola, "The Impact of the Global Financial Crisis on Rural and Microfinance in Asia," Philipp. Inst. Dev. Stud., 2009.

[3] R. Oliva et al., "SMOS radio frequency interference scenario: Status and actions taken to improve the RFI environment in the 1400-1427-MHZ passive band," IEEE Trans. Geosci. Remote Sens., 2012, doi: 10.1109/TGRS.2012.2182775.

[4] E. Daganzo, R. Oliva, Y. Kerr, S. Nieto, P. Richaume, and S. Mecklenburg, "SMOS radiometer in 1400-1427 MHz: Impact of the RFI environment and approach to its mitigation and cancellation," in International Geoscience and Remote Sensing Symposium (IGARSS), 2012. doi: 10.1109/IGARSS.2012.6350594.

[5] Eva Fauziah Ahmad, "Pengaruh Return On Asset, Leverage, Ukuran Perusahaan, Kompensasi Rugi Fiskal Dan Koneksi Politik Terhadap Tax Avoidance (StudipadaSektor Industri Barang Konsumsi yang terdaftar di Bursa Efek Indonesia PeriodeTahun 2013-2017)," J-AKSI J. Akunt. DAN Sist. Inf., 2020, doi: 10.31949/j-aksi.v1i1.172.

[6] G. M. Llanto, "Innovations in the Philippine rural finance system in the 1990s," Borneo Rev., 1991.

[7] V. Bhat, J. S. Trivedi, and B. Dave, "Improving design coordination with Lean and BIM, an Indian case study," in IGLC 2018 - Proceedings of the 26th Annual Conference of the International Group for Lean Construction: Evolving Lean Construction Towards Mature Production Management Across Cultures and Frontiers, 2018. doi: 10.24928/2018/0479.

[8] J. Krampe, C. Rubbelke, N. Reeves, M. Sullivan, and M. Whitten, “Building Evidence,” CIN Comput. Informatics, Nurs., 2016, doi: 10.1097/cin.0000000000000257.

[9] Q. Li et al., “Emission profiles, ozone formation potential and health-risk assessment of volatile organic compounds in rubber footwear industries in China,” J. Hazard. Mater., 2019, doi: 10.1016/j.jhazmat.2019.04.064.

[10] S. M. Lee et al., “Validation of Alternative Methods for Detecting Meibomian Gland Dropout without an Infrared Light System: Red Filter for Simple and Effective Meibography,” Cornea, 2019, doi: 10.1097/ICO.0000000000001892.

CHAPTER 22

AN ELABORATION OF THE FINANCIAL SELF SUSTAINABILITY

Dr.A.K.Singh, Asstt.Professor
SOAS, Jaipur National University, Jaipur, India
Email Id-ashoksingh@jnujaipur.ac.in

ABSTRACT:

In today's economic debate, the idea of financial self-sustainability has become an important topic of discussion. This abstract explores the relevance, guiding principles, and ramifications of financial self-sustainability for people, corporations, and communities alike. Financial self-sustainability provides a viable route to economic stability, less reliance on outside resources, and increased resilience in the face of economic uncertainty by encouraging an atmosphere of self-reliance, careful resource management, and long-term financial viability. In today's dynamic global economic environment, these paper's aims to offer a thorough review of the underlying concepts, difficulties, and viable solutions to promote financial self-sustainability, with a focus on its role in fostering inclusive growth and sustainable development.

KEYWORDS:

Economic Independence, Financial Autonomy, Financial Resilience, Resource Management, Self-Sufficiency, Sustainable Finances.

INTRODUCTION

Achieving stability and sustainability has long been the goal for people, organizations, and communities alike in the field of economics and finance. The idea of "Financial Self-Sustainability" has evolved as a compelling and sought-after objective in a world of constantly changing financial landscapes, promising to change the conventional methods to economic development and resilience. Financial self-sustainability, which is defined as the capacity of a person, group, or society to maintain their financial well-being and meet their needs without heavily depending on outside assistance or resources, is gaining popularity as a paradigm shift for navigating the complexities of a rapidly evolving global economy. Beyond simple self-sufficiency and transient financial advantages, financial self-sustainability is the goal. Instead, it encompasses an all-encompassing, forward-looking perspective that upholds the ideas of wise resource management, long-term planning, and flexibility.

By aiming for financial independence, people and organizations want to build resilient ecosystems that can withstand market fluctuations, manage risks, and promote equitable development. This introduction digs into the many facets of financial self-sustainability, examining its importance, guiding principles, and ramifications for different economic players. We'll examine the main factors influencing this concept's rising popularity and how it threatens to upend long-held beliefs about social advancement, economic growth, and wealth creation. In this investigation, we will look at the essential pillars that support financial self-sustainability, understanding how smart investments, diverse revenue streams, and careful fiscal management may support resilience and long-term viability [1]. Additionally, we will stress the crucial role that financial education and literacy play in enabling people and communities to make wise choices, fostering self-sufficiency and unleashing economic potential.

Even while achieving financial self-sustainability is a worthwhile goal, there are obstacles to overcome. We will discuss the roadblocks and challenges that people and organizations could face, ranging from monetary disparities and capital access to global market dynamics and legislative issues. We can create comprehensive plans and regulations that support an enabling climate for building self-sustaining financial ecosystems by recognizing these obstacles. Finally, we will look at actual instances and case studies of organizations that have effectively embraced financial self-sustainability, examining the strategies they used and the effects they had on the economies and communities in which they operated. These success tales will act as models and sources of motivation for anyone seeking to follow a similar route to monetary independence and toughness. Essentially, this in-depth analysis of "Financial Self-Sustainability" attempts to shed light on a topic that is becoming more and more important and has the capacity to change economies and communities. We can steer society toward a more affluent, secure, and sustainable future for everyone by adopting a vision of self-reliance, responsible financial behavior, and inclusive progress [2].

Self-Sustainability in Money

Yaron (1992 and 1994) assessed the financial self-sustainability of every RFI except those in India. The findings for four RFIs for the years 1987 and 1989 show that all four institutions had significantly different levels of dependency on subsidies based on the subsidy dependence index (SDI), a measure of self-sustainability. The BUD's minimal SDI in these years is 3 percent, suggesting a low reliance in 1987, and 9 percent, indicating an improvement in 1989. The GB's SDI peaks at 180 percent and 130 percent in these two years, respectively, proposing a rise in the on-lending interest rate of 23.9 percentage points, or from 13.3 percent to 37.2 percent annually, to make up for the complete withdrawal of subsidies. In comparison, BKK and BAAC had projected SD is of 24 and 28 percent in 1987 and 20 and 26 percent in 1989, respectively. Over the course of two years, every RFI has improved. In the instance of India, Mosley (2000) calculated that 1 3 institutions, including regional rural banks, had a 133 percent SDI (averaged over the years 1988 to 1992) [3].

i. No Government Intervention and Sound Financial Policies:

It is recommended to follow positive real rates on loans and deposits, savings services, flexible margin and security requirements, interest rebates for on-time loan repayment, a progressive rise in borrowing eligibility after on-time loan repayment, a penalty interest rate on arrears, etc. It is important to evaluate RFIs as soon as possible in terms of outreach and self-sustainability criteria [4].

ii. Sensitization of Bank Staff and NGOs Regarding the Programme:

It is necessary to take action to internalize the relationship between SHGs and banking operations and to educate bankers about how SHGs operate in a certain region. The identification of income-generating activities by members, the mobilization of finance for microenterprise operations, and the marketing and distribution of the members' goods should all be assisted by banks and NGOs.

iii. Obligatory Savings of Members and Effective Delivery Mechanisms:

Savings by members should be linked to lending, and RFIs must guarantee effective and reasonably inexpensive operations, careful loan application screening, and reasonable loan recovery. It should be encouraged to provide regular training for field-level officials and to educate governing and other senior bank officials on the benefits of the SHG path. At regular intervals, the progress should be carefully monitored [5], [6].

iv. Incentives to Bank Staff and Provision of Low-Cost Services:

As seen from the worldwide experience, the staff members working in such programs should be given the proper incentives. Additionally, mobile banking should be implemented to provide extremely low-cost loan and savings services to consumers. Every day of the week, field staff members may go to a different hamlet to collect and distribute funds [7].

Comparison of Grameen Bank and Bank-SHGs Linkage Program

The Grameen Bank (GB) in Bangladesh and the SHG-Bank linkage program in India both have a similar methodology and goal of helping the underprivileged in rural regions. However, a comparison of the two strategies as conducted by NABARD in 1995 reveals the following variations:

i. In India's SHG-Bank connection program, group members make choices about credit and savings, but in Bangladesh's GB method, individuals accept loans and the bank acts as the driving force.

ii. In the Indian context, credit is extended before savings are made, but in the GB model, credit is extended first and then savings are made.

iii. In the SHGs approach, the group's structure serves as a driving force, and in the event of opposition from vested interests, the group's larger membership offers strength to deal with the issues. In contrast, the GB approach places more emphasis on the group's role as a means of influencing member behavior and ensuring accountability.

iv. Under the SHGs model, banks and NGOs both provide group member training; under the GB model, the bank itself provides the training.

v. The GB mechanism essentially bypasses the formal credit machinery on the grounds that it is insufficient, while the SHGs method uses pre-existing formal credit machinery subject to certain controls [8]–[10].

DISCUSSION

Financial self-sustainability is a paradigm shift that emphasizes long-term stability and resilience in the face of economic problems, and it has significant consequences for people, organizations, and society. In this talk, we'll go into more detail about the essential components of financial self-sustainability, including its importance, difficulties, and possible solutions.

i. The Importance of Monetary Self-sustainability

Financial self-sustainability is a systematic approach to economic well-being that encourages independence and lessens exposure to outside economic shocks. It is more than just a desire. In order for people to weather personal financial crises and attain long-term financial stability, it requires careful financial planning, budgeting, and saving. On a larger scale, corporations and organizations work toward self-sustainability by diversifying their sources of income, investing in innovation, and managing risks. By doing this, they may lessen their reliance on outside financing and increase their chances of surviving in cutthroat marketplaces. As communities become less dependent on outside resources and help, self-sustaining financial ecosystems have the potential to promote inclusive development, eliminate poverty, and open doors for socioeconomic progress.

ii. The Financial Self-Sustainability Pillars

Financial self-sustainability is supported by a number of key tenets. These pillars consist of:

a. Caution in Resource Management

Financial self-sustainability must be ensured via efficient resource allocation and management. People and organizations may create solid financial foundations by avoiding wasteful spending and making the best use of their resources.

b. Diversifying Your Sources of Income:

Vulnerability may result from having too much dependence on one source of income. Enhancing financial stability and reducing risks involves diversifying income sources, such as via investments or different revenue streams for enterprises.

c. Long-Term Preparation

It is possible for people and organizations to make strategic choices that are in line with their goals for sustainable development by placing an emphasis on long-term financial planning and goal-setting.

d. Adequate Debt Management:

When used wisely, debt may be a beneficial financial instrument. Financial self-sustainability depends on avoiding excessive debt and following wise debt repayment plans.

iii. The following are obstacles to achieving financial self-sustainability:

Achieving financial self-sustainability is not without difficulties despite the potential advantages. Economic disparities, restricted access to financial resources, and a lack of financial literacy may obstruct certain people's and communities' development toward self-sufficiency. Additionally, for firms and organizations looking to become self-sufficient, external events like shifts in the global economy and changes in legislation may provide concerns. To overcome these obstacles, focused efforts, stakeholder cooperation, and governmental changes that promote a favorable economic climate are all necessary.

iv. Techniques for Promoting Financial Sustainability

At many levels, proactive efforts may be implemented to encourage financial self-sustainability:

a. Financial Inclusion and Education:

People may be equipped with the information and skills necessary to make wise financial choices by investing in financial literacy programs and boosting access to financial services.

b. Support for Public Policy:

By putting in place regulations that promote entrepreneurship, lessen economic inequality, and support sustainable business practices, governments may play a crucial role.

c. Technology and Innovation:

Embracing technology improvements may boost productivity, save expenses, and provide new chances for economic development and self-sufficiency.

d. Environmental and Social Responsibility:

Businesses that incorporate social and environmental responsibility into their operations are more likely to attract investors and customers who value social responsibility, improving their capacity to maintain long-term financial success.

v. Real-World Illustrations

Success stories of people, companies, and communities that have become financially self-sufficient may provide insightful information. These examples provide useful examples for others to imitate, from microenterprises that prosper via microfinancing methods to sustainable firms that place a priority on environmental protection while making a profit. Financial self-sustainability is an innovative strategy for achieving economic success that places a focus on independence, adaptability, and inclusive development. Individuals, companies, and communities may set sail for long-term financial prosperity and a more sustainable future by adopting the concepts of wise resource management, diversification, and responsible financial practices. The key to realizing the revolutionary potential of financial self-sustainability throughout the global economic landscape will be overcoming obstacles and creating supporting conditions.

The idea of "Financial Self-Sustainability" serves as a beacon of hope and change in a society marked by economic instabilities and interdependencies. Through our investigation, we have learned that financial self-sustainability is more than just self-sufficiency; it is a proactive strategy for creating stability, adaptability, and inclusive progress for people, organizations, and society. Financial self-sustainability is important because it has the potential to provide people and organizations with the skills and knowledge necessary to successfully negotiate the intricacies of the contemporary economic environment. Financial self-sustainability provides the path for a more secure and successful future by adopting wise resource management, diversified revenue sources, and long-term planning. However, like with every transformational idea, there are difficulties and barriers to overcome on the way to achieving financial sustainability.

CONCLUSION

Economic disparities, restricted access to financial resources, and global market dynamics might provide obstacles that governments, industry, and civil society must work together to solve. We can realize the full promise of financial self-sustainability by tackling these issues head-on and fostering an enabling atmosphere. The development of financial self-sustainability calls for a multifaceted strategy. This entails making investments in financial literacy and inclusivity, putting in place enabling governmental policies, using cutting-edge technology, and encouraging social and environmental responsibility in company activities. By adopting these tactics, we may influence positive change and build an environment where self-sustainability becomes a realistic objective for everyone. Success stories from the real world have shown that achieving financial self-sustainability is not only a lofty ideal but also a really achievable reality. These examples serve as inspiration and show the transformational power of financial self-sustainability, from microenterprises uplifting communities via responsible financial practices to firms incorporating sustainable principles for long-term success. We may move toward a future marked by resiliency, stability, and sustainable progress by embracing the values of inclusion, self-reliance, and responsible financial behavior. We can create a more prosperous and just society where financial self-sustainability serves as the cornerstone of economic development for future generations by jointly adopting this vision and taking significant action.

REFERENCES

[1] P. Rakotondrajoa et al., "Achieving self-sustainability of service delivery in an eye care program in Madagascar using time-driven activity based costing," BMC Health Serv. Res., 2020, doi: 10.1186/s12913-020-05074-z.

[2] W. Kittilaksanawong and H. Zhao, "Does lending to women lower sustainability of microfinance institutions? Moderating role of national cultures," Gend. Manag., 2018, doi: 10.1108/GM-11-2015-0098.

[3] R. I. Hussain, S. Bashir, and S. Hussain, "Financial Sustainability and Corporate Social Responsibility Under Mediating Effect of Operational Self-Sustainability," Front. Psychol., 2020, doi: 10.3389/fpsyg.2020.550029.

[4] F. Steele, S. Amin, and R. T. Naved, "The impact of an integrated micro-credit program on women's empowerment and fertility behavior in rural Bangladesh," J. Dev. Areas, 2015.

[5] P. Louis, A. Seret, and B. Baesens, "Financial Efficiency and Social Impact of Microfinance Institutions Using Self-Organizing Maps," World Dev., 2013, doi: 10.1016/j.worlddev.2013.02.006.

[6] G. Cairó I Céspedes and L. K. Gómez González, "El enfoque financiero vs. el enfoque social del microcrédito. Un análisis comparativo mundial," REVESCO Rev. Estud. Coop., 2015, doi: 10.5209/rev_REVE.2015.n118.49062.

[7] K. Dineen and Q. V. Le, "The Impact of an Integrated Microcredit Program on The Empowerment of Women and Gender Equality in Rural Vietnam," J. Dev. Areas, 2015, doi: 10.1353/jda.2015.0028.

[8] H. Mohammadifardi, M. A. Knight, and A. A. J. Unger, "Sustainability assessment of asset management decisions for wastewater infrastructure systems—implementation of a system dynamics model," Systems, 2019, doi: 10.3390/systems7030034.

[9] J. Sinthupundaja, Y. Kohda, N. Chiadamrong, and S. Thajchayapong, "Investigating business model innovation for sustainability: Cases from Thailand," Int. J. Innov. Sustain. Dev., 2020, doi: 10.1504/IJISD.2020.108048.

[10] M. Madhooshi, M. Hossein, and J. Samimi, "Social Entrepreneurship & Social Capital : A Theoretical Analysis 2 . The Concept & Features of," Am. J. Econ. Financ. Manag., 2015.