AN ASSESSMENT OF AGRICULTURAL MECHANIZATION INDEX AND EVALUATION OF AGRICULTURAL PRODUCTIVITY OF SOME FAST TRACK RESETTLEMENT FARMS IN BINDURA DISTRICT OF MASHONALAND CENTRAL PROVINCE: ZIMBABWE

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ABSTRACT
The levels of Agricultural mechanization at some farms in two wards of Bindura North district of Zimbabwe were measured and the productivity of each of the surveyed farms was analyzed. The purpose of this study was to determine the degree, level and capacity index of agricultural mechanization in the district. Interviews, observations and a structured questionnaire were used to collect data. Data showed that the average level of mechanization on A1 resettlement farms in the two wards was equal to 0.42 (hp per ha) instead of the estimated standard of 1.5 to 2 hp/ha for optimum productivity of operations. Partial energy expenditure per hectare (mechanization capacity) by energy producing sources (human, animal and machine), was 6.8% for the A1 model and about 60% for the commercial and A2 resettlement farming systems. The level of mechanization in the two wards is pathetic and lower than the expected national mechanization level. Mechanization of the irrigation systems was totally neglected signifying lack of a comprehensive national irrigation policy to buffer the effects of recurrent droughts which are a result of climate change. It was estimated that to reach the mechanization level of 1.5 hp/ha at least 2 tractors per each A1 resettlement farm and an additional of 1 tractor per individual commercial and A2 farmer are required. Profitability was measured in terms of Gross margin analysis of the respective farms. This was measured subjectively as net benefits of physical productivity and the returns from the resources used during production activities. Results show that the average production levels of the two crops, 800kg/ha maize and 900kg/ha tobacco under the A1 resettlement models are far much less than the averages attained elsewhere in the region. This compounded by poor marketing structures and pricing systems means that the majority of farmers are operating below the break-point on the two crops.

KEYWORDS: Agricultural Mechanization; Mechanization Index; Agricultural Productivity; Farm Settlement; Farm Machinery; GoZ; Settlement; Sustainability

INTRODUCTION
Zimbabwe’s second phase of Land Redistribution in the form of Fast Track Land Reform Program (FTLRP), successfully transferred land ownership from the minority, white farmers to the indigenous farmers. As opposed to the initial land policy which aimed at accessing white-
owned land on a willing-buyer and willing-seller basis, but because blacks did not have money to buy the land and whites were not willing to sell the land, the GoZ (2000) had no option except to dispossess the whites and give land to the black majority. By November 2003, 876 farms covering an area of about 976,655 hectares 7.9% of the country’s arable land had been allocated in Mashonaland Central province (Lands Committee Report, 2004). According to (Marimira 2002, quoted by Mukamuri 2003) 14,756 (12%) of the country’s A1 households and 1,684, (23%) of the country’s A2 beneficiaries had successfully been resettled in the province.

However this was followed by a significant drop in agricultural production, as cited by (Obi, 2011) who argue that, the agrarian restructuring of Zimbabwe’s agriculture totally failed to make adequate contributions to the nation’s economic development. Zimbabwe, once so rich in agricultural produce that it was dubbed the "bread basket" of Southern Africa, faced numerous challenges agriculturally, and now struggles to feed its own population, as about 45 percent of the population is malnourished (FAO, 2010).

In an effort to resuscitate the agricultural sector the Government of Zimbabwe (GoZ, 2007) launched a massive mechanization program after realizing that the newly resettled farmers were not capacitated to till the land. The programs though noble, never yielded desired results, as these were characterized with ad-hoc policies and accelerated reforms which negatively impacted the agricultural sector. In initiating the mechanization program the government’s intention was to support the land reform program and improve food productivity among the newly resettled farmers (Chatizwa and Khumalo, 1996) this objective however never yielded desired results, raising fears for the program initiators.

Research on agro-based successful economies of African countries such as Nigeria, Ghana and South Africa reveals that knowledge on farming practices can be passed on to new generations if sustainability is to be maintained in the sector. Between 1980 and 1999 Zimbabwe’s agricultural sector grew steadily, producing a diverse range of domestic and export commodities. Moyo (2004) cited that agriculture contributed over 40% of national exports and 18% of GDP, and employed 70% of the population. Its complex agro-industrial linkages could not be underestimated as it provided 60% of the raw materials to the agro-based industries. Agricultural production however depended heavily on imported inputs and machinery, which relied on stable export revenues, external commercial credit and balance of payments support.

Production became vulnerable to dramatic decline after the FTLR mainly due to the fact that the beneficiaries of the land reform/ new farmers did not have their own stocks of farm machinery and equipment. The other assumption was that the displaced LSC farmers either sold their machinery and equipment, exported machinery to the neighbouring countries, or have warehoused their equipment in anticipation of favourable settlement of their acquisition court contests (Moyo, 2004). In addition, the current macro-economic conditions –high interest rates and lack of foreign currency – have made it difficult for new farmers to acquire machinery. The government has through the District Development Fund (DDF), made efforts to alleviate these constraints but the general assessment has been that of shortage of machinery and equipment for servicing the new farming communities. It is therefore imperative that the study tries to assess the current status, demands and machinery resource requirements for the reformed sector to recover from the current slump.
Background to the Study

To make a reliable plan to develop the agriculture of a region, it is important to gain a precise knowledge of the existing situation and the problems facing the development of agriculture. Otherwise, any long-, middle-, and short-term plans will be ineffective and finally problematic and they will lead to a waste of capital and time. This is of crucial importance in undeveloped countries because of limited capital and economic depression. However there are many areas with potential for development in these countries. One of the main reasons, and probably the most important one, for this kind of social structure is the dependence of these countries on traditional agricultural systems with a low level of efficiency hence remaining victims of food insecurity. Therefore, attempts to find a solution to enhance the effectiveness of agriculture in the economy of these countries must be taken into consideration as one of the main goals.

By definition, the mechanization of agriculture is the "application of mechanical implements or as a whole, the application of the state-of-the-art technologies in agriculture to increase productivity and to reach sustainable agriculture". There are three specific indices for the study and evaluation of mechanization in different regions. These indices include degree, level, and capacity of mechanization (Almasi et al., 2000). Tools, implements and powered machinery are essential and major inputs to agriculture. The term mechanization is generally used as an overall description of the application of these inputs (Clarke, 2000). The level, appropriate choice and subsequent proper use of mechanized inputs into agriculture has a direct and significant effect on achievable levels of land productivity, labour productivity, the profitability of farming, the sustainability, the environmental and, on the quality of life of people engaged in agriculture (Olaoye and Rotimi 2010).

Starkey (1998) defined farm mechanization as the development and introduction of mechanized assistance of all forms and at any level of sophistication in agricultural production to improve efficiency of human time and labour. Increased levels of farm power and mechanization is therefore one of the major factors required to increase production. The present state of mechanization in Zimbabwe’s agriculture is still far from increasing the rate of farming incomes and productivity. This is because mechanization plan has not been formulated following a well designed, reliable and thorough analysis (Nwoko, 1990). Chisango and Obi (2011) highlighted that a series of mechanization phases, following the Fast Track Land Reform in Zimbabwe were poorly planned and chaotically implemented. This investigation was carried out in Matepatepa area of Bindura district in Mashonaland central province to study the situation of mechanization in the region and to analyze the relevant qualitative and quantitative issues.

 Principally agricultural mechanization involves the use of tools, implements and machines to improve the efficiency of human time and labour. The most appropriate machinery and power source for any operation depends on the work to be done, cultural settings, affordability, availability and technical efficiency of the options. These indications were clearly evident that agricultural mechanization is not an end in itself, but a means of development that must be sustained. Therefore a socially beneficial agricultural production is determined based on a wide range of social, economic and ecological factors. These factors determine whether a technology is practicable, beneficial and sustainable in an area (Olaoye and Rotimi 2010).
The agrarian restructuring of Zimbabwe’s agriculture has failed to make adequate contributions to the nation’s economic development (Obi, 2011). This failure of agricultural industry especially in newly resettlement areas can be attributed to the absence of an appropriate level of agricultural mechanization. Anozodo et al., (1986) as cited by Olaoye and Rotimi (2010) observed that the application of human, animal and mechanical equipment in agriculture with reference to technical, socio-economic and cultural constraints of farms can be acknowledged in the continuing official promotion of primitive hand tool technology characterized by low production efficiency.

FAO, (1981) affirmed that Zimbabwe, from the first decade of its independence in 1980 had experienced failure in improving the farm mechanization through various agricultural policies that were implemented. Ou et al. (2002) reported that agricultural mechanization as system engineering requires not only advances in machine development and applications but also the close cooperation of many sections. In recognition of this fact, certain environmental, agricultural, social and economic conditions must be ascertained to favor investment in mechanization technologies and their sustainable use. Timeliness of tillage and planting, weeding and/or harvesting are critical factors where affordable labour is insufficient to permit timely operation. Other key factors that influence successful mechanization include Socio-economic factors, supporting infrastructure, land and agro-ecological conditions, and technical skills and service (Olaoye, 2007).

Ozmerzi (1998) affirmed that the agricultural mechanization level of a country is technically expressed in terms of hp/ha standard being 1.5/2hp/ha, kW/ha, ha/tractor, number of tractors/1000 ha, equipment weight/tractor and mechanical power/total power. Zimbabwe’s current level and practice of agriculture is characterized by low level of utilization of farm machinery and associated implements for farm operations. The strategy for a shift from the traditional concept of hand tools technology to achieving sufficiency in food could be undertaken through capacitating the District Development Fund DDF, the sole tillage service provider for the resettled farmers and the rural communities. Promoting coexistence and linkages between the former white commercial farmers and the beneficiaries of the land reform has been an underestimated option which can be exploited for the benefit of the new farmer. These innovations would provide production conditions that will be technically feasible and socio-culturally compatible with production technologies.

However after the formation of the GNU in 2008 not much of that massive program has been said leading to some opponents having the general perception that the program has suffered a still birth. The agricultural mechanization, which was introduced to strengthen the land reform program, came to a halt at the advent of the inclusive government as other principals were reluctant to prioritize funding for agriculture. As critical food shortages persist to threaten most counties in the country many blame these shortages on the poorly planned and chaotic, extensive land redistribution and mechanization programs which have resulted in significant backward shifts in agricultural production.

The proponents of the programs however blame food shortages on drought and the cumulative effect of sanctions imposed against the country by the west and the declining national budgetary allocation to the sector by the country’s ministry of finance. They argue that years following the
formation of the GNU were characterized by deliberate under-funding and prioritization of agriculture, hence exposing the sector to numerous challenges which crippled it performance. Scoones, (2010) argues that the previous claims that Zimbabwe’s reform programs were a failure, due to the fact that the primary recipients were political "cronies" or that they caused rural collapse were unfounded. He attributed the challenges to the complexity and the differences in experience, witnessed across the farms.

Before 2000 land-owning farmers had large tracts of land and utilized economies of scale to raise capital, borrow money when necessary, and purchase modern mechanized farm equipment to increase productivity on their land. As the primary beneficiaries of the land reform and mechanization programs had little or no experience in running different enterprises on a farm, the drop in total farm output has been tremendous and has even produced starvation and famine, according to FAO, (2007). Mostly crops for export have suffered severely, e.g. Zimbabwe was the world's 6th largest producers of Tobacco in 2001. It produces nowadays less than 1/3 of the amount produced in 2000, the lowest amount in 50 years. Zimbabwe was once so rich in agricultural produce that it was dubbed the "bread basket" of Southern Africa, but now has become a dust bowl and is struggling to feed its own population. About 45 percent of the population is now considered malnourished.

Up till this present time, Zimbabwe has not been able to define the economic role of sustainable agricultural mechanization that can transform the chaotic experimental phase presently existing in the resettlement farms to a sound commercial position. Zimbabwe needs to embark on sustainable mechanization because there is current national awareness on the immense potential of agriculture as second to the mining sector, in boosting the economy of the country. The nation can achieve this goal through accelerated food production by increasing both labour and land productivity as well as expanding areas of cultivated land. The main objective of this paper is to evaluate the level of agricultural mechanization application and farm productivity of some selected wards of Bindura district in Zimbabwe.

Statement of the problem

A major agricultural production backward shift occurred during and after the FTLRP—this affected major crops and livestock, particularly those traditionally produced by large-scale commercial farmers. Maize and tobacco in Mashonaland Central Province, experienced both reduced area plantings and output volumes by about (30-70%) (Moyo, 2004). The optimal utilization of available land by the newly resettled farmers was constrained by limited access to inputs, such as machinery, equipment, and irrigation infrastructure. The fall in the average yields of specialized crops such as tobacco and wheat reflected deficiencies in the use of irrigation resources, and lack of experience as many of the farmers were producing the crops for their first time ever. In an effort to resuscitate the agricultural sector the Zimbabwean government launched the mechanization program which never impacted positively on productivity as the majority of people continue to face serious food shortages (FAO, 2009).

Again shortage of labor-force as some ex-farm workers followed their former employers to the neighboring countries meant that the new farmers were deprived of adequate skilled and experienced farm labor. In cases where labor is available it is highly mobile as workers freely
move from one farm to another in search of better wages. Women workers and child labor-force
now perform difficult tasks initially reserved for men on the farms, hence productivity remains
low.

Gold panning in the province has also created a more lucrative alternative source of income for
some former farm workers. Wages from gold panning are much higher than farm labor rates and
this creates labor scarcities for both newly resettled farmers and the remaining LSCF farmers. In
an effort to realize the gains of the FTLR, mechanization can therefore be viewed as the only
missing link for the agricultural sector to recover from the current slump. This study therefore
aims at assessing the needs and aspirations of the farming community in terms of mechanization,
technical capabilities, and marketing strategies for a viable and sustainable agriculture.

Broad Research Question

How do newly resettled farmers and traditional commercial farmers view and describe the
impact of mechanization on the level of production and production efficiencies on their farms?

Specific research questions are:

Which mechanization machinery and equipment do farmers have for specific crop enterprises—
maize and tobacco, on their farm holdings

What machinery and drought power source do farmers have for efficient maize and tobacco
production on their farms?

In which areas do farmers need knowledge and skill in machinery utilization to boost the levels
of crop productivity on the farms

METHODOLOGY

Site Selection

Two wards in Matepatepa area of Bindura district were surveyed. Bindura district is
characterized by a wide variety of land tenure typologies, namely: communal areas (Musana,
Masembura and Chiweshe), newly resettled small scale (A1), newly resettled large scale (A2),
small scale commercial, large scale commercial and old resettlement areas). The district though
having absolute and comparative advantages in intensive and semi intensive agricultural
activities, it is also made up of areas of varying agricultural potential ranching from agro-
ecological zone 2 receiving as much as over 1000mm of rainfall annually (Felton farms in
Matepatepa) to agro-ecological zone 4 which receives as little as below 450 mm of rainfall per
year, signifying special need for the resuscitation of irrigation systems in the district.

The Research Design

It is paramount that in seeking answers to the broad research question a case study design was
used. A case study is “an empirical inquiry that investigates a contemporary phenomenon within
its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 2003). Case study allows the researcher to grasp a holistic understanding of the phenomenon under investigation (Creswell, 1998; Eisenhardt, 1989). Instead of seeking answers to questions such as “how much” or “how many,” case study design is useful for answering “how” and “why” questions (Benbasat et al., 1987; Yin, 2003). In the study the “how” and “why” questions addressed the critical issues of declining levels of agricultural productivity in the province after the launch of FTLR and the mechanization programs initially viewed as the panacea for the challenges facing the agricultural sector in Zimbabwe.

Integration of the Case Study Design with the Grounded & Interpretive Theories

Grounded theory, which is the discovery of theory from data” (Glaser & Strauss, 1967) provided the opportunity for the researcher to theorize from evidence existing in the data. The major advantage of grounded theory to this study was its inductive, contextual, and process-based nature as cited by (Charmaz, 2006; Orlikowski, 1993; Strauss & Corbin, 1990). These characteristics proved to be particularly useful for the research. Incorporation of the interpretive theory provided the basis upon which quantitative and qualitative data was used.

Population and sampling procedure

Data gathering is crucial in any research, as the data is meant to contribute to a better understanding of a theoretical framework (Bernard 2002). It then becomes imperative that selecting the manner of obtaining data and from whom the data will be acquired be done with sound judgment. Selection criteria of participants should aim at selecting people willing to impart their knowledge and experiences on mechanization programs pre and post Zimbabwe’s independence. The purposive/judgmental sampling technique—most effective when one needs to study certain cultural domains with knowledgeable experts has been found to be the most suitable tool for the study. The flexibility of purposive sampling in using both qualitative and quantitative research techniques was advantageous to this research.

Population and sample size

From a provincial population of 998,265, Zimbabwe’s Fast Track Land Reform Program (FTLRP) of 2000 successfully resettled a total population 14,756 households under A1 model and 1,684 beneficiaries under A2 farming. The study used data from 80 Fast Track Resettlement farmers, and a control group of 10 traditional commercial farmers, purposively sampled. A stratified random sampling technique was used to select 80 Resettled farmers in the study area.

DATA COLLECTION

Data collection is simply how information is gathered. There are various methods of data collection such as personal interviewing, observations, surveying, and use of questionnaires. The choice of method is influenced by the data collection strategy, the type of variable, the accuracy required, the collection point and the skill of the enumerator. The study used both qualitative and quantitative methods in collecting and analyzing data. Quantitative methods formed the backdrop of the study while the qualitative data provided a detailed explanation of the findings.
Data collection techniques

Qualitative data collection technique used

Interviews

An interview is a series of questions a researcher addressed personally to the respondents. Both structured (clearly defined questions) and unstructured, questioning led by the responses of the interviewee were used. Interviews were advantageous in discovering how individual farmers thought and felt about impacts of mechanization on the current trends of agricultural performance and why farmers had such opinions. The researcher also found interviews to be ideal when dealing with sensitive issues which people would feel uncomfortable discussing in focus groups. This provided deeper understanding and a more detailed explanation on statistical data.

Quantitative data collection technique

Questionnaires

A questionnaire with a series of written questions was supplied to respondents, requesting their response. The way the data were to be analyzed influenced the layout of the questionnaire. The questionnaire made use of closed questions which provided boxes for the respondents to tick (hence provided easily coded information). The study avoided open questions as these would require respondents to write answers, though giving more freedom of information; they had a drawback of being more difficult when coding.

Analytical tools

Mechanization index: qualitative and quantitative criteria by which the impact of mechanization on productivity was used to identify the significance of draft power sources and machinery on productivity and production efficiencies of maize and tobacco in Matepatepe area. Gross Margin Analysis was used to investigate the economic significance/viability of mechanization in relation to crop productivity per given unit of land.

PRESENTATION OF RESULTS

Measurement of Agricultural Mechanization Index

Degree of Agricultural Mechanization

According to Nowacki, (1974), cited by (Olaoye and Rotimi, 2010), the assessment and grading of the level of mechanization was classified as: hand tools (M1) = 1, animal drawn (M2) = 2, Tractorized (M3) = 3.
For the purpose of this study, the index of mechanization was limited to the prominent available power sources in Matepatepa area of Bindura district, Zimbabwe (M1 and M3). The degrees of mechanization of the two available power sources were defined as follows:
Degree of Mechanization M1 is the average energy input of work provided exclusively by human power (labour) per hectare: it is indicated as (Nowacki, 1974);

\[ LH = 0.1 \cdot NH \cdot TH / A \]  
(Equation 1)

Where;
- LH = average energy input or work provided per hectare by human labour kWhr/ha.
- NH = average number of labour employed.
- TH = average rated working time devoted to manual operation

0.1 = Theoretical average power of an average man working optimally.

A = Area of land cultivated (ha)

\( A \) was determined for each farm settlement in the two wards of Matepatepa area, by multiplying areas of cultivated land in hectares allocated to each participating farmer by the total number of farmers and \( TH \) was determined as a function of rate of energy consumption and resting period for different manual operations (planting, weeding, fertilizer application and harvesting).

According to Caruthers and Rodriguez, (1992), resting period \( tR \) was defined as follows:

\[ tR = 60(1 - 250/P) \]

Where:
- \( tR \) = required resting time for 8 hrs effective working hrs per day in minute per hour of work
- \( P \) = rate of power consumption in watts for various farming activities.

Degree of Mechanization M3 represents the first degree of mechanization, motorized machinery coexisting with a high participation of workers (Nowacki, 1974). It is indicated as;

\[ LM = 0.2 \cdot NM \cdot TM / A \]  
(Equation 2)

Where;
- LM = Average energy input or work per hectare by motorized machines
- 0.2 = Corrector coefficient of the tractor-powered machine.
- NM = rated working power of the tractor (kW)
- TM = rated working time of the motorized energy source, hr/ha
- A = Area worked in hectare by motorized machines.

\[ \text{Effective field capacity } C = \frac{\text{SWE}}{10} \]  
(Equation 3)
TM = 1/C

Where:
C = effective field capacity, ha/hr
W = width of cut of implements, m
EF = field efficiency%
S = Operating speed, m/s

DBP = S.D/3.6 (kW) \textbf{(Equation 4)}

Where:
S = operating speed, m/s.
D = draft, representing total force parallel to the direction of travel required to propel the implement KN/m.

Nm = DBP/0.74 (kW) \textbf{(Equation 5)}

Where:
0.74 is the average value of the tractive and transmission coefficient on firm soils ranging from 0.73 to 0.75 for 80% loading as characterized by the textural soil type of the surveyed areas.

\textbf{Determination of Index of Mechanization}

Mechanization index, (M I), represents the percentage of work of the tractors in total of human work and that of the machinery. It was calculated using Eq. 6 below (Nowacki, 1974);

\[ WME = \frac{LM}{LT}.100\% \textbf{(Equation 6)} \]

Where:
WME = Mechanization Index %
LM = average sum of all mechanical operation work of the machine, kWhr/ha
LT = sum of all average work outlays by human and tractor powered machines, kWhr/ha
LT = LM + LH

Parameters for TH and LH were determined based on the exact response of the average farmers in the surveyed areas on the estimated resting period in minute per hour of work on each manual operation.

\textbf{Measurement of the Productivity of Machine and Human Labour}

Productivity may be conceived of as a measure of the technical efficiency of production which is characterized by a shift of the production function and a consequent change to the output / input relation. The productivity of machine and human labour could be determined based on the principle of production schedule which represent the maximum amount of output that can be produced from any specific set of inputs given the existing technology. The input of labour and capital are the explicit independent variables in the production function measured in terms of man-hours and in machine-hours and their relations as shown by the Equation below (Jhingan, 1997).
Q = F (K, L) (Equation 7)

Where:
Q = the output, F = functional relationship, K = the amount of capital
L = the amount of labour

The productivity of labour, machine, and total productivity were obtained from Ortiz-Canavate and Salvador (1980), cited by (Olaoye and Rotimi, 2010), as presented in the two Equations below.

AM = 1/ LM (Equation 8)

AH = 1/LH (Equation 9)

AT = 1/ LH + 1/ LM (Equation 10)

Where:
AM = productivity of machines, defined as the work carried out in function of the machinery employed
AH = productivity of labour, defined as the work carried out in function of labour employed
AT = total productivity and all other terms as defined previously.

Gross Margin Analysis for the Production of Major Arable Crops (Maize & Tobacco) in the Surveyed Areas of Bindura district

The profitability was determined using gross margin analysis. The gross margin is obtained from the expression given in equation 14 by Jhingan, (1997).

\[(GM) = TR – TC \] (Equation 11)

Where:
GM = Gross Margin/gross profit value TR = Total revenue (P x Y)
P = Price
Y = Yield tons/ha or kg/ha
TC = Total Cost (FC+VC)
FC = Fixed Cost
VC = Cost of the variable inputs

Values of all farm labour in the district were based on the prevailing agricultural wages per day US$4 and the prevailing market prices were used for variable inputs and outputs. These were estimated on the probable rates of returns based on the conditions as at the time of the study.

Results and Discussions

Socio-Economic characteristics and Demographic Data of the Farm Settlers.

Majority of the farmers in the schemes are above 40 years of age. About 9.05% of the farmers are illiterate and 24.3% have gone up to primary level (Table 1). This influences their level of awareness to adopting new innovations, which can create motivation to change, and enhance productivity. The beneficiation of mechanization inputs for production and other services has
been partially based on the level of education and the skill the farmers had since the gathered data indicated that a few who benefitted had attained tertiary education. As a result machinery which was supposed to be generally owned and operated cooperatively to secure greater efficiency are now basically the responsibility of a few individual settlers.

Table: 1 Relative distribution of educational level in the research study areas of Bindura district

<table>
<thead>
<tr>
<th>Name of farm settlement</th>
<th>Total number of settlers</th>
<th>NIL</th>
<th>Primary School</th>
<th>Secondary School</th>
<th>Tertiary Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatumba A1</td>
<td>36</td>
<td>2</td>
<td>6</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Felton A1</td>
<td>60</td>
<td>5</td>
<td>15</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Morio A1</td>
<td>30</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Kajasuma A1</td>
<td>67</td>
<td>8</td>
<td>20</td>
<td>29</td>
<td>10</td>
</tr>
<tr>
<td>Argylpark A2</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Felton A2</td>
<td>9</td>
<td>-</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Piedmont A2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Chiveri A2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>G-Total</td>
<td>210</td>
<td>19</td>
<td>51</td>
<td>96</td>
<td>44</td>
</tr>
<tr>
<td>Overall %</td>
<td></td>
<td>9.05%</td>
<td>24.3%</td>
<td>45.7%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Marital status of households
Sample farmers were classified based on their marital status. The marital status is classified in four categories namely: single, married, widowed and divorced. Figure 1 shows that the distribution of households by marital status portrays a general trend of male dominance in most households. As illustrated below most household heads about (61%) are married, while the least percentage of 8% was registered on widowed participants.

![Figure 1: Distribution of households by marital status](image)

Source: Field survey conducted (2013)
In an African family set-up, the husband and wife play complementary roles with regards to their livelihoods. For instance, while the wife performs the day to day household chores such as cooking for the family, and small scale farming activities such as gardening for food security, the husband might be involved in income generating activities such as farming at a larger scale and other non farming activities such as formal employment. In the absence of a spouse, one can encounter a situation where he or she has to perform duties on behalf of the other. In this regard, the extent to which he or she can be expected to undertake farming activities would be expected to differ from married spouses. The implication of this scenario is that a household comprising husband and wife is better off than a single headed household in terms of sharing responsibilities and activities on the farm which may lead to specialization and a boost in agricultural production.

**Labor availability**

The human resource component of a farming enterprise is an important element in agricultural production. It is through man’s ability that production inputs are integrated and made compatible with one another in order to produce desired results. Man is therefore considered as the origin and destination in the production process. De Klerk (1980) says human element is a key factor in agricultural and rural development due to its importance in decision making which is regarded fundamental to good management and successful farming. Bembridge (1987) says the biological, social, economic and psychological aspects of a farming community influence the efficiency of farming operations and dictates the communication patterns and technology transfer for agricultural development.

![Figure 2: Type of labour available to survey farmers](#)

*Source: Field survey conducted (2013)*

The employment of family labor by the majority of farmers could be traced to the scale of operation, rudimentary technology of production and missing labor markets. This finding is linked to the finding by Dorward (1999) that smallholder farming is characterized by usage of
family labor. However, the fact that the majority of farmers in the surveyed area employ family labor might suggest the farming limitations encountered by the farmers in the district. Neighbors and visiting relatives constitute a fraction of about (6%) which can be an indication that neighboring households could be having surplus labor to spare.

**Households with Access to Tillage/draught Power**

An investigation on mechanization capacities of individual farmers shows that the A1 newly resettled farmers have huge deficits on machinery inputs. It was established that in all the surveyed farms, farmers had only limited access to animal draught power and none of them significantly benefited under the mechanization programs. The observation reveals that farmers still heavily rely on traditional hand tools hence exposing farmers to drudgery and poor crop productivity. The observed scenario however shows that a few of those who benefited were under the A2 resettlement model.

**Table: 4 Households with Access to Tillage/draught Power**

<table>
<thead>
<tr>
<th>Province</th>
<th>Number of households with access to tillage/draught power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatumba</td>
<td>5</td>
</tr>
<tr>
<td>Felton 1</td>
<td>18</td>
</tr>
<tr>
<td>Marioto</td>
<td>6</td>
</tr>
<tr>
<td>Kajasuma</td>
<td>20</td>
</tr>
<tr>
<td>Felton 2</td>
<td>3</td>
</tr>
<tr>
<td>Argylpark</td>
<td>2</td>
</tr>
<tr>
<td>Piedmont</td>
<td>1</td>
</tr>
<tr>
<td>Chiveri</td>
<td>0</td>
</tr>
</tbody>
</table>

*Source: FOSENET, 2003*

**Index of Agricultural Mechanization**

The practice of selective mechanization was prominent in all the farm settlements. Mechanical operations were restricted only to tillage operations such as ploughing, discing and ridging. Other operations like planting, weeding, fertilizer application and harvesting are manually done. This is because of the deficient standardization and non-availability of mechanization inputs to serve the whole scale of production. This is an indication that the programs did not witness visible application of modern techniques. The study revealed that low production efficiency, drudgery, under utilization of mechanical power, and uses of old tractors with constant break down during operation, contributed to low level of mechanization with the highest level of about
30% for the commercial and A2 farming sectors in the two wards and least level of 10.4% for A1 settlement schemes.

The work outlay (LM: machines, LH: Human labour) were determined for various farm settlements and Table 2 presents various work outlays for the power sources investigated. The timeliness in operation for tractor power was determined by giving consideration to the width of cut (W) of the implement, operating speed, and machine efficiency. While for human labour, TH, were determined by giving consideration to total resting period per hour of work per day as expressed in Equation.1. The index of mechanization for each farm was determined using Equation 3 and the result is presented in Tables 2 and 3 showing that as index of mechanization increase, energy input per land area in hectare by human work is greater than the energy input of machine .This is because great work capacity and more time of utilization of the human work are needed for the same area (Olaoye and Rotimi, 2010).

**Table: 2 Energy used for mechanical operations in wards 3 & 5 of Matepatepa, Bindura (kWhr/ha)**

<table>
<thead>
<tr>
<th>Farm Operations</th>
<th>Farm settlements</th>
<th>Felton 1</th>
<th>Moriota</th>
<th>Kajasuma</th>
<th>Argylpark</th>
<th>Felton 2</th>
<th>Piedmont</th>
<th>Chiveri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ploughing</td>
<td>Gatumba</td>
<td>0.4</td>
<td>0.8</td>
<td>0.2</td>
<td>1.0</td>
<td>4.2</td>
<td>0.8</td>
<td>16.4</td>
</tr>
<tr>
<td>Discing</td>
<td></td>
<td>1.2</td>
<td>2.6</td>
<td>0.8</td>
<td>2.8</td>
<td>10.8</td>
<td>8.4</td>
<td>12.2</td>
</tr>
<tr>
<td>Ridging</td>
<td></td>
<td>0.08</td>
<td>0.02</td>
<td>0.04</td>
<td>0.09</td>
<td>6.4</td>
<td>0.8</td>
<td>10.6</td>
</tr>
<tr>
<td>Planting</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.02</td>
<td>8.2</td>
<td>4.7</td>
<td>8.4</td>
</tr>
<tr>
<td>Herb-appn</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.2</td>
<td>0.2</td>
<td>4.2</td>
</tr>
<tr>
<td>Fert-appn</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>0.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Harvesting</td>
<td></td>
<td>0.4</td>
<td>0.02</td>
<td>0.03</td>
<td>0.2</td>
<td>4.2</td>
<td>2.1</td>
<td>10.2</td>
</tr>
<tr>
<td>Processing</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Work output**

**Table: 3 Summary of the Level of Mechanization in Relation to Total Output Power, Human productivity, Machine Productivity and Total Productivity per Unit Areas of Cultivated Land**

<table>
<thead>
<tr>
<th>Farm Settlements</th>
<th>Area of land cultivated for arable crops (ha)</th>
<th>Actual tractor s/farm (+60hp) working</th>
<th>Actual animal power (0.8-1hp)</th>
<th>Actual human power (0.4-0.5hp)</th>
<th>Level of Mechanization (available hp)</th>
<th>Maize Productivity TPP/tons/kg</th>
<th>Tobacco Productivity TPP /kg</th>
<th>Total physical productivity (for the 2crops)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatumba</td>
<td>108</td>
<td>-</td>
<td>12</td>
<td>12</td>
<td>14.4</td>
<td>28.8</td>
<td>29,600</td>
<td>58.4</td>
</tr>
<tr>
<td>Felton 1</td>
<td>172</td>
<td>-</td>
<td>30</td>
<td>14</td>
<td>29.6</td>
<td>186</td>
<td>6,436</td>
<td>192.4</td>
</tr>
<tr>
<td>Moriota</td>
<td>75</td>
<td>-</td>
<td>10</td>
<td>8</td>
<td>11.2</td>
<td>26.4</td>
<td>28,260</td>
<td>54.7</td>
</tr>
<tr>
<td>Kajasuma</td>
<td>170</td>
<td>1</td>
<td>28</td>
<td>16</td>
<td>88.8</td>
<td>96.6</td>
<td>41,140</td>
<td>137.7</td>
</tr>
<tr>
<td>Felton 2</td>
<td>160</td>
<td>3</td>
<td>8</td>
<td>30</td>
<td>198.4</td>
<td>278</td>
<td>5,000</td>
<td>283</td>
</tr>
<tr>
<td>Argylpark</td>
<td>210</td>
<td>4</td>
<td>4</td>
<td>40</td>
<td>339.2</td>
<td>422</td>
<td>60,000</td>
<td>482</td>
</tr>
<tr>
<td>Piedmont</td>
<td>120</td>
<td>3</td>
<td>2</td>
<td>80</td>
<td>273.6</td>
<td>240</td>
<td>180,000</td>
<td>420</td>
</tr>
<tr>
<td>Chiveri</td>
<td>60</td>
<td>-</td>
<td>4</td>
<td>20</td>
<td>14.4</td>
<td>60</td>
<td>22,400</td>
<td>82.4</td>
</tr>
</tbody>
</table>
Productivity
Productivity of the machine and labour were determined using Equations 11 to 13. The variability between productivity was compared to the areas of cultivated land and index of mechanization for each farm to identify the contribution and efficiency of the variable input power source in terms of returns to the factor of production. Data on the physical productivity of land (crop yields) is a function that depends on the magnitude of the mechanization inputs. These were recorded to justify whether the quality of land degradation, erosion and effect on environmental pollution can be improved over time. The estimate of crop yield ranges from 0.8 to 6.0 tonnes / ha for maize and from 1500 to 4000kgs / ha for tobacco (Tables 5 and 6) below. Figure 1 and table 3 show that productivity of variable inputs increases proportionately with increased area of the farm. The indication is that the level of economic resources available to farmers determines production technology for crops under farmers’ production conditions, that is, the probability of adopting technology and effective utilization of the said energy sources are expected to increase beyond the mean level as the farm size increases. This serves as a tool to identify from farmers’ perspective the contribution, effectiveness and efficiency of the variable input including power sources in terms of returns to the factors of production. Lack of information and inability of the settlers to conduct operative performance of their activities based on the structural and functional capabilities of the available power options were the reasons for the low production level as observed from the small scale/A1settlement areas in the district.

Economic Justification of Gross Margin Analysis

Table: 5 Gross Margin Analyses on Maize Production

<table>
<thead>
<tr>
<th>Items</th>
<th>Price/Item in US$</th>
<th>Average price N/kg/lt</th>
<th>Recommended input Quantity kg/lt/ha</th>
<th>Expected optimal Yield/output tons/ha</th>
<th>Average obtainable yield tons/ha</th>
<th>Output (Farm gate price/kg/ton) US$</th>
<th>Total Output market(P x Y) US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed/seedlings (tobacco)</td>
<td>$60/25Kg</td>
<td>2.40</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer basal &amp; top dressing</td>
<td>$36/ 50kg bag &amp; $30/bag</td>
<td>0.72&amp;0.60 cents</td>
<td>250-300&amp;250-300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land preparation/ploughing, discing &amp; ridging</td>
<td>$70/Ha, $50&amp; $50 respectively</td>
<td>1.35/lt</td>
<td>25-30&amp;20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plantating</td>
<td>$50/Ha</td>
<td>1.35/lt</td>
<td>15-20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labour on weeding &amp; harvesting</td>
<td>$40&amp;40/Ha respectively</td>
<td>64/lhr or 4/ld</td>
<td>8&amp;2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curing &amp; grading/shelling</td>
<td>$40</td>
<td>32/lhr</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging &amp; transportation &amp; transportation</td>
<td>$40/20bags &amp;60/Ton</td>
<td>2/empty bag &amp;3/bag</td>
<td>20</td>
<td>60-120bags (3-6tons/ha)</td>
<td>800/1000</td>
<td>0.25/kg</td>
<td>0.30/kg</td>
</tr>
</tbody>
</table>
Table 6 Gross Margin Analysis on tobacco Production

<table>
<thead>
<tr>
<th>Items</th>
<th>Price/Item N/kg/lt</th>
<th>Average price N/kg/lt</th>
<th>Recommended input Quantity kg/lit/ha</th>
<th>Expected optimal Yield/output kg/ha</th>
<th>Average obtainable yield kg/ha</th>
<th>Output (Farm gate price/kg/ton) US$</th>
<th>Total Output market (P x Y) US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed/seedlings (tobacco)</td>
<td>300 TRB seedlings/ha</td>
<td>0.02/seedling</td>
<td>15000 seedlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer basal &amp; top dressing</td>
<td>46 basal/bag &amp;36 top/bag</td>
<td>0.92/kg &amp; 0.72</td>
<td>14 &amp; 2 bags</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land preparation/ploughing, discing &amp; ridging</td>
<td>$70/Ha, $50 &amp; $50 respectively</td>
<td>1.35/lt</td>
<td>25-30 &amp; 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planting</td>
<td>80</td>
<td>1.35/lt</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labour on weeding &amp; harvesting</td>
<td>180/Ha respectively</td>
<td>96/lhr or 12/ld</td>
<td>12lds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curing &amp; grading/shelling</td>
<td>120</td>
<td>64/lhr</td>
<td>8lds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging &amp; transportation</td>
<td>$300/25 bale &amp; 75 pairs &amp; 375Transport</td>
<td>12/bale &amp; 15 respectively</td>
<td>4000kg</td>
<td>1500kg</td>
<td>0/kg</td>
<td>3/kg</td>
<td></td>
</tr>
</tbody>
</table>

The small size of farm holdings of (2 -5) ha allocated to each settler has encouraged the intensity of continuous cultivation on the same piece of land which does not permit good cultural management practices like crop rotation and lay farming recommended for tobacco cultivation. Therefore, intensity of cultivation on the same plot resulted in loss of soil fertility together with absence of soil and moisture conservation. The uniformity of the pattern and size of holdings as allocated to each settler failed to take recognition of variance in settlers’ income potential, farming experience, and innovation adoption skills. Former farm workers were allocated a maximum of 2ha per household undermining their resource endowment and farming experience. Tables 5 and 6 show that for the same rate of agronomic inputs, the total cost of production inputs, including the cost of performing field operations was found to be $ 690 per hectare for maize and $ 2,240 for tobacco on selectively mechanized operations. Lack of guaranteed price level of farm produce at the farm gate and local markets constitute the main constraints discouraging settler farmers from cultivating at reasonably large scale.

Breakeven analysis showed the financial efficiency on the commercial and A2 farming systems in the study area where it was between the range of 110% and 145%. Based on the rates determined by Anazodo (1985), a project is not economically viable to be invested in if the financial efficiency is less than 100%, a common feature on most of the surveyed A1 settlements. Although this implies that selectively mechanized system of the two crops under the
different farming models in the area is economically justified but with relatively low benefit cost ratio despite the 100% subsidies given to some selected few farmers who got machinery and mechanization equipment for free.

This analysis can provide a basis for a more systematic recommendation and estimation of the type, size, number and capital investment for selectively mechanized resettlement farm project in order to increase farmers’ income. Muchow et al. (2002) reported that a mechanized system must be used to serve a large area to produce a reasonable scale benefit. If the planning scale is too small, the fixed cost per unit area would be high and result in an economical loss as the case for most A1 farmers in Matepatepa area. Possible solutions to increase the gross margin can be achieved through additional cultivated area, favorable input price changes, additional product values per area (additional yields or output price changes) and additional production / processing values. All these are means of increasing profitability.

A graphical representation below justifies the scenario by showing the relationship between human productivity, machine productivity and total productivity per unit area of cultivated land.

![Graph: Productivity responses to variable inputs and land size](image)

**Fig: 3 Productivity responses to variable inputs and land size**

**Source:** Olaoye and Rotimi, (2010)
CONCLUSIONS

Evaluation of the level of agricultural mechanization and agricultural productivity of some farm settlements in two wards of Matepatepa area in Bindura district, Zimbabwe was carried out. The primary focus of this paper was on the way the fast track land reform programme and the follow up agricultural mechanization programme have impacted on the smallholder sector in terms of their importance in explaining variations in earnings. Related to this was the need to ascertain the extent to which the sector has made use of the opportunity afforded for enhanced access to the vital resources of land and farm machinery.

The level of agricultural mechanization was established by deriving a relationship between the various source of farm power and the level of human involvement. The Agricultural mechanization index was then deduced for the various sources of farm power and the level of productivity for each of the sampled farm settlement was determined as an inverse of the work outlay of the explicit factors involved in production function (capital or machine and labour).

The study revealed that low production efficiency, drudgery, under utilization of mechanical power, and uses of old tractors with their constant break down during operation, contributed to low level of mechanization. The study does find that the expected positive relationships between key productive inputs and farm performance still hold for Zimbabwe. This is important for policy since it confirms that incentive mechanisms can still be effectively manipulated to achieve real growth if attention is paid to the rational allocation principles devoid of political influence as has been the case in recent years. What seems to be lacking, as confirmed by a large number of studies, is proper planning. Without a doubt, proper planning is non-negotiable for a land reform programme to successfully deliver the benefits of equitable distribution of land and enhanced agricultural productivity.

Gross margin Analysis was established for the assessment of the average physical productivity (Crop yields) and the returns from the resources engaged in agricultural production on major available crops in each of the surveyed farms. For the same rate of agronomic inputs, the total cost of production inputs, including the cost of performing field operations was found to be $690 per hectare maize and $ 2240 per hectare for tobacco produced under mechanized systems. The indication is also that purchased inputs such as seeds and fertilizer strongly influence gross income in the farming systems studied. Narrow gross margins especially on the small-holder A1 resettled farmers; suggest high degrees of inefficiencies in resource use in the smallholder system. Thus, while mechanization and land reform can potentially contribute to gross income growth, there is clear evidence of sub-optimal resource utilization which is consistent with generally-held views about the arbitrariness and poor planning that have characterized Zimbabwe’s recent economic management processes.

Recent evidence from other parts of Zimbabwe (Obi, 2010) has shown that without proper planning, land reform can lead to supply bottlenecks as a result of declining productivity and production. Some of the effects have already been felt in the weakening of the primary markets that serve smallholders, with negative consequences for smallholder livelihoods and welfare. There is definitely a mismatch there and an anxiety to appeal to sectional sentiments. As serious as Zimbabwe’s economic crisis can be, it does not qualify to mount the largest farm
mechanization programme on the continent where most of the beneficiaries of the land reform programme are either absent from the farms or lack the skills to utilize the resources put at their disposal. It is also unclear how Zimbabwe can afford to finance the “largest farm mechanization programme in the whole of Africa”.

Technical efficiency at the production level is also meaningless in the absence of enhanced market access. And real marketing is impossible in the absence of goods and services. So there is a two-way link. Anything that chokes off supply of physical output is bound to weaken primary markets serving the poor. Policies to empower small farmers by re-distributing land in order to boost food production and link them to markets must undoubtedly be sensitive to these issues.

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