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Decision Support System (DSS) for Maximization of Available Tractor Power

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Abstract

The design support system for maximization of available tractor power is a project designed for a mono-functional purpose of calculating all the parameters involved in tractor power maximization. This paper explicitly focuses on the conjunction of model driven decision support systems (DSS) which is a branch of decision support systems that deals with manipulation of a statistical, financial, optimization, or simulation model which has significant effect of agricultural practices(especially in farm-mechanization).

Reduction of Power losses in farm mechanization which is considered inevitable but can be inhibited by having a substantial knowledge of the formulae/models involved in tractor power maximization which would subsequently bring about an increase in power output and financial profit. A window and android based software application written with Java programming language and Extensible markup language (XML) was developed as a direct solution to the problem and this will not only increase farmers profit and output but will also describe how modelling and computerization can be of symbiotic benefits especially in an era where models of window based software are now incorporated into mobile phones for easier mobility and flexibility.

This should enhance the awareness of computerisation in agriculture and subsequently make farm mechanization monitoring easier for all categories of farmers .

The Available models include; Drawbar Power, Power take off power, Hydraulic power, Travel speed, Wheel slip, Wheel power, tractive efficiency and fuel consumption rate.

Key-Words: - Decision Support System, Development, maximization, model, software and tractor power

1.0 Introduction

While agriculture is the practice of cultivating the soil, raising livestock to produce plant, animals useful to humans and in some instances animals, agricultural inputs relate to those vital elements to be used to make agriculture both possible and profitable. These inputs are resources required to cultivate the land, produce crops including forestry, livestock including fishery, process, and store and distribute them. Agricultural inputs must therefore include diverse elements such as land, capital and labour as well as research, education, communication/information, and engineering/technology. All these inputs and many more constitute agricultural mechanization which must be harnessed, controlled and organized for improved agricultural practice. For mechanization management to succeed, some other inputs upon which it will strive must be available. These include good and focused political manner of governance capable of formulating and implementing policies and laws that can accelerate the process of economic growth and development. Mechanization management should address the challenges facing the future of food demand and supply as enunciated by Raoult-Wack and Bricas (2001).

One of the cradles of mechanization in Agricultural engineering is the advent of computer programming which has been used to develop various farm power related models and simplify equations. Further development of this models resulted into development of various agricultural software and machines.

Tractor power maximization connotes how to justifiably harness(put to maximum use or function) all the power dissipated by the tractor engine to the various power units of the tractor simultaneously minimizing power losses while evaluating their performance with various mathematical models e.g. Drawbar power, Hydraulic power, implement width, tractive efficiency etc.

The objectives of this paper includes the review of decision support systems relating it to the available models for maximizing tractor power and developing a software using the models. Power units in the tractor includes the following: Drawbar, Power take off and Hydraulic

(www.mindat.org).

2.0 COMPUTERS IN AGRICULTURE

2.1 Weather Prediction

For as long as agriculture has existed, the success of the harvest has been driven by the weather. Ideally, crops will get the right amount of rain and sun to produce the highest yield. Since modernization of weather forecasting has come into play, predicting the weather has obviously become exponentially easier. Nowadays, farmers have direct access to computerized weather forecasting. This allows them to properly manage their lots to maximize yield. Much of this weather forecasting is done with computers, but how?

The most important tool to predicting weather in the future is observing the current state of the weather. Forecasters use observations taken from satellites (which take up to 210 million observations per day!) to predict what might happen. These observations are recorded in a computer, and are ready to be used in the computer models. Using data based on temperature, pressure, precipitation, and more, forecasters can run one of hundreds of computer models designed to predict what might happen. The models are based on past weather events as well as local geography (elevation, high or low pressure, e.t.c.). The farmers in turn use the forecast predicted by the computerized weather model to gauge how much rain will be coming in, as well as how dry the upcoming weather will be, amongst other factors (Sunil, 2011)..

2.2 Record Keeping

Computers play an important role in record keeping in the agriculture field. Farmers use computers to keep track of information such as budget records, animal health and tracking forms, equipment inventories, and maps of land. Livestock farmers can use computer technology to track the health and status of each of their animals. This is called herd recording. Such records include an animal's age, health records, milk production, offspring production, and their reproductive cycle. There is software and programs to help organize and keep record of this information for the farmers making it easy to keep track of their livestock and run the farm more efficiently.

Farmers need to have a detailed and accurate compilation of records in order for their business to operate smoothly. Computers allow farmers to organize this information that is easily accessed and is presented in a clear, organized manner. Double-entry-computer-accounting systems coordinate information such as taxes, money management, and plant details. Farmers use maps to plot areas of land with certain characteristics that might affect crop yield. To do this, farmers use GPS and map these areas in computer programs. Computers are extremely important and a conducive tool to farmers which aide in the process of running their farms more efficiently and therefore making their products more assessable to consumers! (Sunil, 2011).

2.3 Farmer Communication

The communication of information is an important part of the agricultural domain. Throughout its history, farmers have shared knowledge about everything from growing strategies to market prices. Pest epidemics, droughts, and other farming issues are bound to arise and advice from other farmers can help with handling these problems. With modern technology, farmers can quickly communicate questions about adapting to sudden weather changes or other concerns. Applications and devices have improved accuracy, such that research related to the supply chain, item tracking, increasing yields, etc. is fast and convenient. With the rising Global Food Market, Information and Communication Technology (ICT) has become increasingly important for agriculture (Sunil, 2011).

An ICT is a tool or application that allows the exchange of data through transmission. ICTs can include anything from a small device such as mobile phones, or nanotechnology for food safety, or even satellite imagery. Small-scale farmers can benefit from understanding developments in global agriculture. Where industrial-scale producers utilize digital tools and technologies, small-scale farmers rely primarily on experience and word-of-mouth. For example, they may seek information in the following areas:

(i) Markets & Pricing
(ii) Plant Varieties
(iii) Farm and Production Techniques
(iv) Processing and Distribution
(v) Advancements in Tools and Equipment

ICTs are extremely accessible and have the potential to protect small-scale farmers from falling behind the "technology curve," while increasing their incomes and protecting their livelihoods.

2.4 GIS

According to the United States Environmental Protection Agency, Geographic Information Systems is "a computer system that allows you to map, model, query, and analyze large quantities of data within a single database according to their location" (Geographic Information Systems). GIS allows you to:

(i) Construct maps
(ii) Combine information
(iii) Make scenarios
(iv) Present ideas
(v) Develop solutions

GIS is used in a ranking system called precision agriculture, which evaluates and assesses land. The kind of information stored in this system is as follows:

(i) Soil conditions
(ii) Drainage conditions
(iii) Slope conditions
(iv) Soil pH
(v) Nutrient status

These organizational systems allow farmers to have insight into conditions that could affect their crops and their success. Before the use of GIS and precision agriculture, farmers lacked control about essential information that relates to fertilizer application and problems with drainage, insects, and weeds (Sunil, 2011).

The use of GIS is a money saver and increases efficiency. It also leads to better decision making about where and when to produce crops. GIS greatly improves communication as farmers can access the vital information and use it to their advantage and produce a higher yield of healthier crops. GIS helps improve agricultural record keeping. It does this by compiling various data in an easily assessable system that farmers can look at. All in all GIS helps farmers tremendously in the upkeep and functions of their land and crops (Geographic Information Systems, 2014).

2.5 Automated Farm Equipment

The topic of automated farming is very interesting. It brings combines technology and farming into another dimension. With technology, the farming industry can go to new heights. It is not a very new idea, some farms have been using automated farming equipment for a long time to help boost their numbers of final products. Companies are working to provide farmers with affordable automated farming machines. They claim to provide farmers with the tools they need to be a successful.

Another important field of interest pertaining to automated farming equipment has to do with autonomy. Economists have studied this issue in detail. Looking at the history of farming, crop-growing has come a long way- from physically exhausting to machines to the hard work. We see a huge shift in what is desirable as well. Instead of appreciating the hard work from the farmer, we now see appreciation in numbers and size of fruits and vegetables. This reflection of our society gives way to the value of the automated farming machines. We take advantage of technology to do the hard work, and consequently, hold less appreciation for the finished product (Sunil, 2014).

2.6 E-Agriculture

E-Agriculture is a community of people devoted to the exchange of information and ideas to work towards rural and agricultural development. On the official E-Agriculture website, their mission is defined; "Our Mission is to serve as a catalyst for institutions and individuals in agriculture and rural development to share knowledge, learn from others, and improve decision making about the vital role of ICTs to empower rural communities, improve rural livelihoods, and build sustainable agriculture and food security". Information is shared whenever there is demand for such information. For example, say an entrepreneur (like a farmer) wants to begin exporting crops, but is unsure of the market standards regarding sustainability. By communicating their demand for knowledge of such standards via computer, (be it on forums, online programs, or e-mail), the entrepreneur is likely to receive the information. This transaction is all run through the community of E-Agriculture (Dorfman, 2014).

2.7 Decision Support Systems

The concept of decision support has evolved from two main areas of research: The theoretical studies of organizational decision making done at the Carnegie Institute of Technology during the late 1950s and early 1960s, and the technical work on Technology in the 1960s. Keen (1978)

DSS became an area of research of its own in the middle of the 1970s, before gaining in intensity during the 1980s. In the middle and late 1980s, executive information systems (EIS), group decision support systems (GDSS), and organizational decision support systems (ODSS) evolved from the single user and model-oriented DSS (Taylor, 2012).

According to Sol (1987) the definition and scope of DSS has been migrating over the years. In the 1970s DSS was described as "a computer-based system to aid decision making". In the late 1970s the DSS movement started focusing on "interactive computer-based systems which help decision-makers utilize data bases and models to solve ill-structured problems". In the 1980s DSS should provide systems "using suitable and available technology to improve effectiveness of managerial and professional activities", and towards the end of 1980s DSS faced a new challenge towards the design of intelligent workstations.[5]

In 1987, Texas Instruments completed development of the Gate Assignment Display System (GADS) for United Airlines. This decision support system is credited with significantly reducing travel delays by aiding the management of ground operations at various airports, beginning with O'Hare International Airport in Chicago and Stapleton Airport in DenverColorado. Beginning in about 1990, data warehousing and on-line analytical processing (OLAP) began broadening the realm of DSS. As the turn of the millennium approached, new Web-based analytical applications were introduced.

The advent of more and better reporting technologies has seen DSS start to emerge as a critical component of management design. Examples of this can be seen in the intense amount of discussion of DSS in the education environment. Power (2002)

3.0 Methodology

A Review of the best models for tractor power maximization, Power take off, hydraulic power, drawbar power, fuel consumption, travel speed, tractive efficiency, wheel slip and wheel power were considered.

Window and android based solutions was designed for the models and Post development testing was carried out to test the implemented packages.

The required criteria used for this research covered the parameters that are the strategic decisions used, their attributes, the model development and its manual application for results generation.

3.1 Taxonomy of decision supporting systems

Using the relationship with the user as the criterion, Haettenschwiler differentiates passive, active and cooperative dss. A passive dss a system that aids the process of decision making, but that cannot bring out explicit decision suggestions or solutions. An active dss can bring out such decision suggestions or solutions. a cooperative dss allows the decision maker (or its advisor) to modify, complete, or refine the decision suggestions provided by the system, before sending them back to the system for validation. the system again improves, completes, and refines the suggestions of the decision maker and sends them back to them for validation. the whole process then starts again, until a consolidated solution is generated (Power, 1996).

Another taxonomy for dss has been created by daniel power. using the mode of assistance as the criterion, power differentiates communication-driven dss, data-driven dss,document-driven dss, knowledge-driven dss, and model-driven dss. Power (2002).

(i) Communication-driven dss supports more than one person working on a shared task; examples include integrated tools like google docs or groove.

(ii) Data-driven dss or data-oriented dss emphasizes access to and manipulation of a time series of internal company data and, sometimes, external data.

(iii) Document-driven dss manages, retrieves, and manipulates unstructured information in a variety of electronic formats.

(iv) Knowledge-driven dss provides specialized problem-solving expertise stored as facts, rules, procedures, or in similar structures.

(v) Model-driven dss emphasizes access to and manipulation of a statistical, financial, optimization, or simulation model. model-driven dss use data and parameters provided by users to assist decision makers in analyzing a situation; they are not necessarily data-intensive. dicodess is an example of an open source model-driven dss generator (Gachet, 2004).

Using scope as the criterion, power differentiates enterprise-wide dss and desktop dss. an enterprise-wide dss is linked to large data warehouses and serves many managers in the company. a desktop, single-user dss is a small system that runs on an individual manager's personal computers. (Power, 2002).

This paper involves using different models for tractor power maximization so it focuses more on the model-driven dss under the scope of the single user dss in which in recent years can also be used not only on user's desktops but also on android applications and other mobile phones.

3.2 Software development and computerizing models

The development of software applications for mobile computers has been recently spurred by the availability of more powerful operating systems and the transfer of standardized programming languages on ever-smaller computing platforms. These developments have opened the door for creating new applications that bring computing power to field scientists and engineers (Vivoni et al., 2001)

3.3 Drawbar power

Until the 1940s, ploughs and other tillage equipment usually were connected to the tractor via a drawbar. The classic drawbar is simply a steel bar attached to the tractor (or in some cases, as in the early Fordsons, cast as part of the rear transmission housing) to which the hitch of the implement was attached with a pin or by a loop and clevis. The implement could be readily attached and removed, allowing the tractor to be used for other purposes on a daily basis. If the tractor was equipped with a swinging drawbar, then it could be set at the center or offset from center to allow the tractor to run outside the path of the implement. The drawbar system necessitated the implement having its own running gear (usually wheels) and in the case of a plough, chisel cultivator or harrow, some sort of lift mechanism to raise it out of the ground at turns or for transport. Drawbars necessarily posed a rollover risk depending on how the tractive torque was applied. The Fordson tractors (of which more units were produced and placed in service than any other farm tractor) was extremely prone to roll over backwards due to an excessively short wheelbase. The linkage between the implement and the tractor usually had some slack which could lead to jerky starts and greater wear and tear on the tractor and the equipment. A large, modern John Deere model 9400 four-wheel drive tractor with tripled wheels and a drawbar-towed tool chain, including one-pass tillage equipment, planter and fertilizer applicator with tanks Drawbars were appropriate to the dawn of mechanization, because they were very simple in concept and because as the tractor replaced the horse, existing horse-drawn implements usually already had running gear. As the history of mechanization progressed, however, the advantages of other hitching systems became apparent, leading to new developments. Depending on the function for which a tractor is used, though, the drawbar is still one of the usual means of attaching an implement to a tractor.

3.3.1 Equation for drawbar power.

To determine drawbar power, some parameters must be put into consideration and they include;

(i) Drawbar pull or the drawbar tensional force
(ii) The rate of distance travelled i.e. Speed
(iii) A constant which is stated as 3600.
Therefore;

$$\text{Drawbar power (watts)} = \frac{\text{force(newton)} \times \text{Speed(km/hr)}}{\text{constant (3600)}}$$

3.4 Hydraulic power

Three-point hitches and quick hitches, The drawbar system was virtually the exclusive method of attaching implements (other than direct attachment to the tractor) before Harry Ferguson developed the three-point hitch. Equipment attached to the three-point hitch can be raised or lowered hydraulically with a control lever. The equipment attached to the three-point hitch is usually completely supported by the tractor. Another way to attach an implement is via a quick hitch, which is attached to the three-point hitch. This enables a single person to attach an implement quicker and put the person in less danger when attaching the implement. A modern three-point hitch revolutionized farm tractors and their implements. While the Ferguson system was still under patent, other manufacturers developed new hitching systems to try to fend off some of Ferguson's competitive advantage. For example, International Harvestor's Farmall tractors gained a two-point "Fast Hitch", and John Deere had a power lift that was similar to, but not as flexible as, the Ferguson invention. Once the patent protection expired on the three-point hitch, it became an industry standard. Almost every tractor today features Ferguson's three- point linkage or a derivative of it. This hitch allows for easy attachment and detachment of implements while allowing the implement to function as a part of the tractor, almost as if it were attached by a fixed mount. Previously, when the implement hit an obstacle, the towing link would break or the tractor could flip over. Ferguson's genius was to combine a connection via two lower and one upper lift arms that were connected to a hydraulic lifting ram. The ram was, in turn, connected to the upper of the three links so the increased drag (as when a plough hits a rock) caused the hydraulics to lift the implement until the obstacle was passed. Recently, Bobcat's patent on its front loader connection (inspired by these earlier systems) has expired, and compact tractors are now being outfitted with quick-connect attachments for their front-end loaders. Power take-off systems and hydraulics In addition to towing an implement or supplying tractive power through the wheels, most tractors have a means to transfer power to another machine such as a baler , swather , or mower . Unless it functions solely by pulling it through or over the ground, a towed implement needs its own power source (such as a baler or combine with a separate engine) or else a means of transmitting power from the tractor to the mechanical operations of the equipment. (www.mindat.org)

Early tractors used belts or cables wrapped around the flywheel or a separate belt pulley to power stationary equipment, such as a threshing machine, buzz saw, silage blower, or stationary baler. In most cases, it was not practical for the tractor and equipment to move with a flexible belt or cable between them, so this system required the tractor to remain in one location, with the work brought to the equipment, or the tractor to be relocated at each turn and the power set-up reapplied (as in cable-drawn ploughing systems used in early steam tractor operations) (www.mindat.org).

3.4.1 Equation for Hydraulic power

The equation for calculating hydraulic power includes;

Hydraulic power (kilowatt)= $\frac{\text{Guage pressureP(newton)} \times \text{FlowrateQ}}{\text{constant (1000)}}$

3.5 Power Take Off power

Modern tractors use a power take-off (PTO) shaft to provide rotary power to machinery that may be stationary or pulled. The PTO shaft generally is at the rear of the tractor, and can be connected to an implement that is either towed by a drawbar or a three-point hitch. This eliminates the need for a separate, implement-mounted power source, which is almost never seen in modern farm equipment. Virtually all modern tractors can also provide external hydraulic fluid and electrical power to the equipment they are towing, either by hoses or wires.

3.5.1 Equation for Power Take Off.

This is calculate using the rule –of- thumb multiplying factor which takes into account the type of soil you will experience and the factors are shown in this table 1.

Table 1: Various Soil Condition

Soil condition	Multiply drawbar kw by
Firm untilled soil	1.5
Previously tilled soil	1.8
Soft or sandy soil	2.1

Therefore;

Power take off power (kilowatt) = Required drawbar power × multiplying factor.

3.6 Travel Speed

Field travel speed is a major factor in matching tractor to implement. For many operations, the most desirable travel speed is from 5 to 7 miles per hour (6.4 to 9.7 kph) because most implements are designed to perform high-quality work at these speeds. Travel speeds below 4 mph (6.4 kph) result in low field capacities, poor soil mixing for tillage operations, and reduced life of the drive train except for certain operations, such as planting, where precise control is required. Operating equipment at high speeds generally increases implement maintenance, increases tire wear, and reduces the life of the implement. It can also break down soil aggregates, which leads to compaction. Field speeds may be limited by heavy yield, rough ground, operator skill, or downed crops. Irregular and small fields overlap, and large machinery can affect field efficiency.(www.mindat.org)

3.6.1 Equation for Travel speed

The equation for calculating Travel speed includes;

Travel speed = $\frac{\text{Distance,load}}{\text{time(seconds)}}$

3.7 Fuel Consumption

Ability to predict tractor fuel consumption is very useful for budgeting and management. The objective of this factsheet is to develop relationships using field measurements and Nebraska Tractor Test Laboratory results to estimate tractor fuel consumption. Using these equations, farmers can estimate and compare the fuel consumption for different operating and loading conditions.

Depending on the type of fuel and the amount of time a tractor or machine is used, fuel and lubricant costs will usually represent at least 16 % to over 45 % of the total machine costs. Thus, fuel consumption plays a significant role in the selection, management of tractors and equipment used in agriculture. Currently, most budget models use simplified methods for estimating fuel consumption. Better estimates representing actual field operations are needed to compare machinery management strategies.

The worth of a tractor is assessed based on work output and the cost associated with completing the task. Drawbar power is defined by pull (or draft) and travel speed. An ideal tractor would convert all fuel energy into useful work at the drawbar. However, due to power losses, not all fuel energy is converted into useful work.

Efficient operation of farm tractors may depend on: maximizing the fuel efficiency of the engine and the mechanical efficiency of the drivetrain, maximizing tractive efficiency of the traction devices, and selecting an optimum travel speed for a given tractor-implement system. This factsheet focuses on methods to estimate and improve fuel efficiency of a diesel power unit.

Fuel consumption is measured by the amount of fuel used during a specific time period. The most common measure of the energy efficiency of a tractor is referred to here as “specific volumetric fuel consumption” (SVFC), which is given in units of gallons per horsepower-hour (gal/hp-h). Specific volumetric fuel consumption is generally not affected by engine size, and it is used to compare the energy efficiencies of tractors with different size engines and under different operating conditions. SVFC for diesel engines typically ranges from 0.0476 to 0.1110 gal/hp-h. (www.cigrjournal.org)

For ease of computation, the reciprocal of SVFC is often used and is referred to here as “specific volumetric fuel efficiency” (SVFE) with units of horsepower-hours per gallon (hp-h/gal), with corresponding ranges from 12 to 21 hp-h/gal.

Farmers may consider numerous ways to estimate and reduce fuel consumption. The first step is to determine how much fuel is being used for a particular field operation and compare it to average usage. This measurement can be completed by filling the fuel tank of the tractor before and after a field operation, noting the number of acres covered. The number of gallons used, divided by the number of acres covered, gives the fuel consumption in gallons per acre (gal/ac). If measured fuel consumption is higher than the estimated average, the following tips should be considered to reduce fuel consumption:

(i) Eliminate one or more tillage/field operations.

(ii) Substitute one type of tillage operation for another.

3.7.1 Equation for Tractive Efficiency

Equation for Fuel consumption includes;

Fuel consumption = $\frac{\text{fuel consumed(gallons/litres)}}{\text{time taken(seconds)}}$

3.8 Tractive Efficiency

Tractive efficiency (TE) is the ratio of drawbar power to axle power and can be estimated when slip is known. TE (and hence tire efficiency) of a wheel can be predicted using a series of equations that take into account tire dimensions, soil conditions, slip, etc. Tractor performance is calculated by summing the individual wheel performances. (www.cigrjournal.org)

3.8.1 Equation for Tractive Efficiency

The equation for calculating tractive efficiency includes;

Tractive efficiency = $\frac{\text{Drawbar power}}{\text{wheel power}} \times 100$

3.9 Wheel slip and Wheel power

Tire slip occurs when the tires are turning faster than the ground speed of the tractor. As a result, less than 60% to 70% of the power that a tractor engine develops is used to pull an implement through the soil. It could even drop to 50% on soft and sandy soils. Some of the power developed by a tractor engine is lost in hydraulic systems, transmissions, cab air conditioners, and other applications. However, most of the power is lost in transmitting power from the tires to the soil. It may seem as if efficiency would increase without any slip; however, that is not the case.

There must be some slip between the tires and the soil surface for an efficient operation.

Limited slip improves tractive efficiency, which is the ratio of drawbar power to axle power. Slip also provides a safety valve against shock overloads that could damage the power train; some wheel slippage is needed to reduce wear on the power train. However, too little slip anchors the tires to the soil because of too much ballast, so power and fuel are wasted in trying to move the tractor through the soil. A balance must be found where slip is optimized.

For the most efficient operation, slip should be near the peak tractive efficiency. Notice that the peak tractive efficiencies occur between 8 to 15% slip, depending on soil types and conditions. For every 1% past optimal slip, you lose an equivalent 1% in productivity and reduce your energy efficiency. Tractors and tires should be maintained to optimize wheel slippage at 10% to 15%. Less slippage than this results in the expenditure of too much fuel

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energy to move the wheels, whereas too much slippage (greater than 15%) can result in excessive tire spin and energy loss through the tire, which is nonproductive. www.eXtension.org

3.9.1 Optimizing Wheel Slip

Equation for Wheel slip includes;

$$\text{Wheel slip} = \frac{m0 - m1}{m0} \times 100$$

Where

m0 = distance without load

m1 = distance with load.

Equation for Wheel power includes;

Wheel power = Transmission Efficiency × Engine Power

4.0 Results

After running the java program, the following interfaces were shown and units were used to test the implemented package. The following are the steps involved while running the program.

Plate 1: Main Menu

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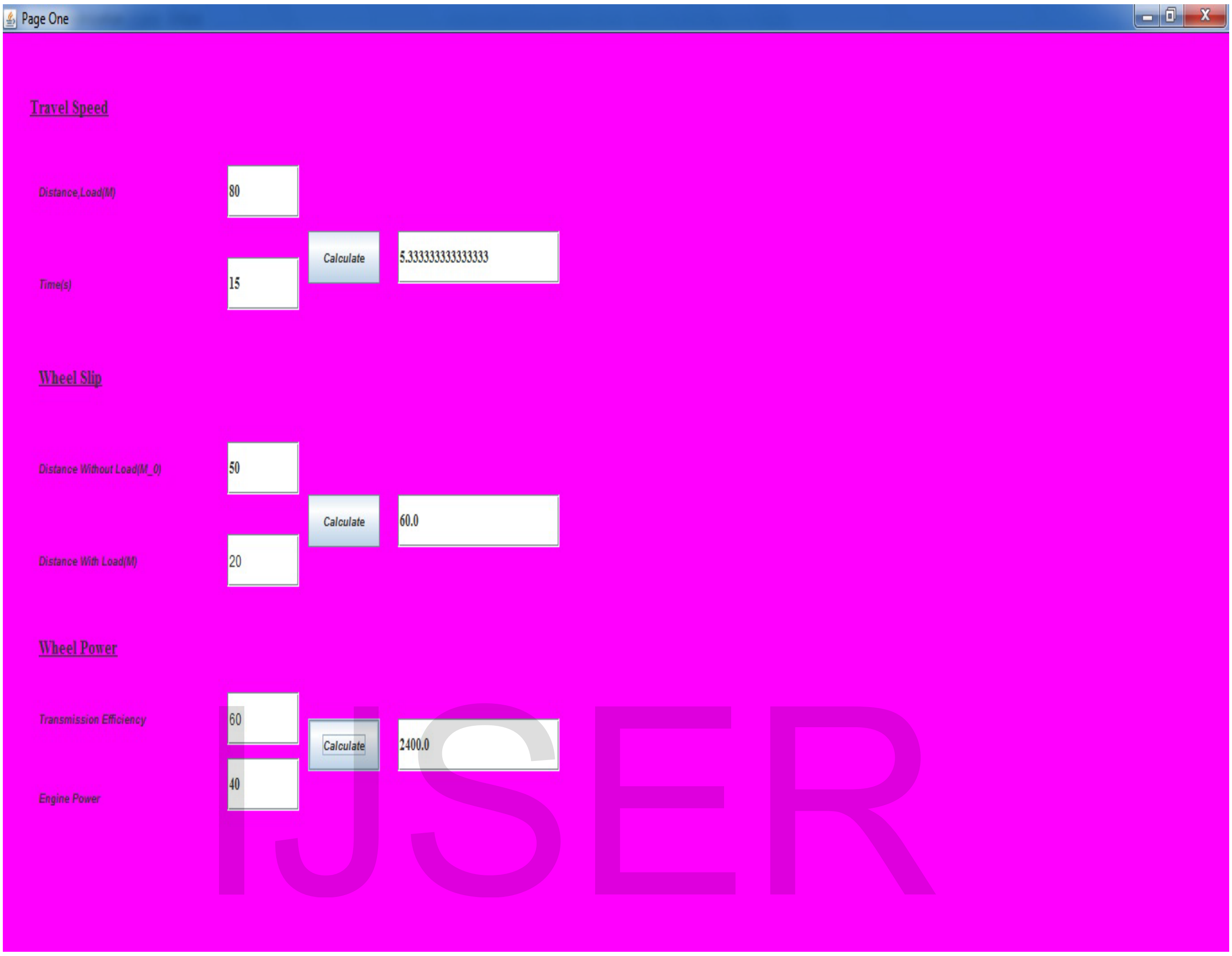


Plate 2: Data Input

Plate 3: Data Generated

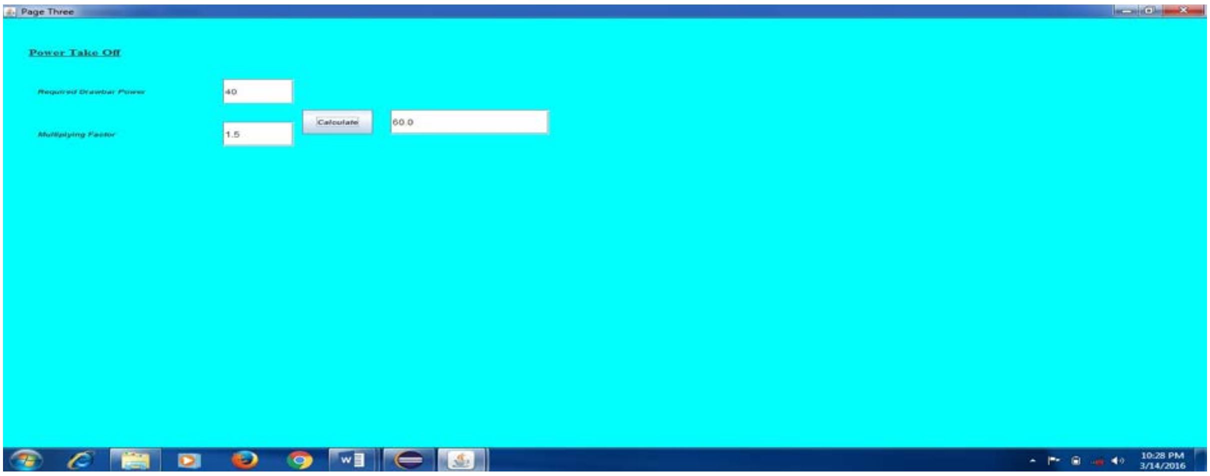


Plate 4: Units Menu

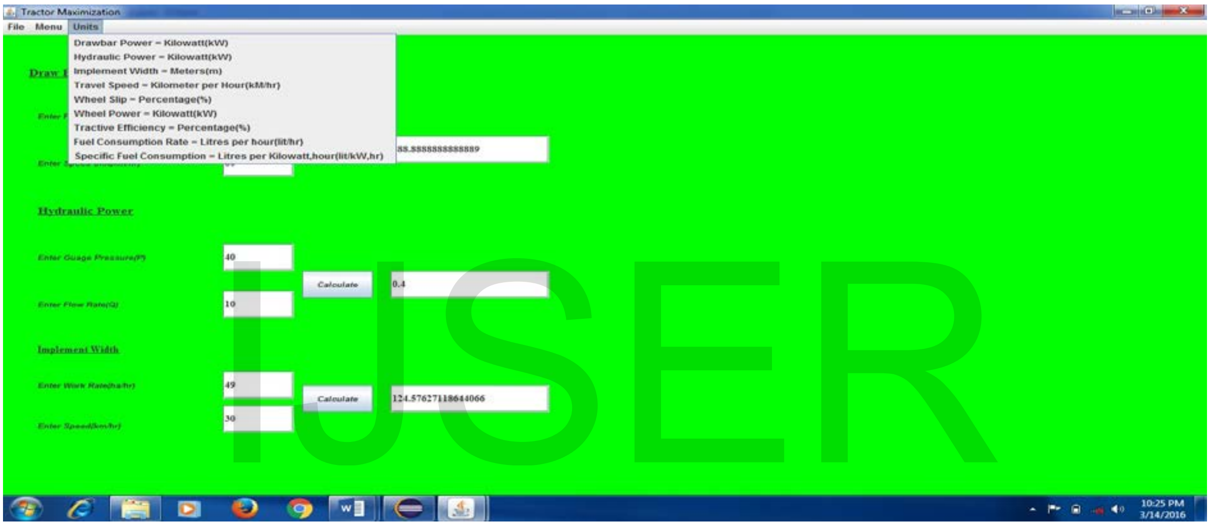
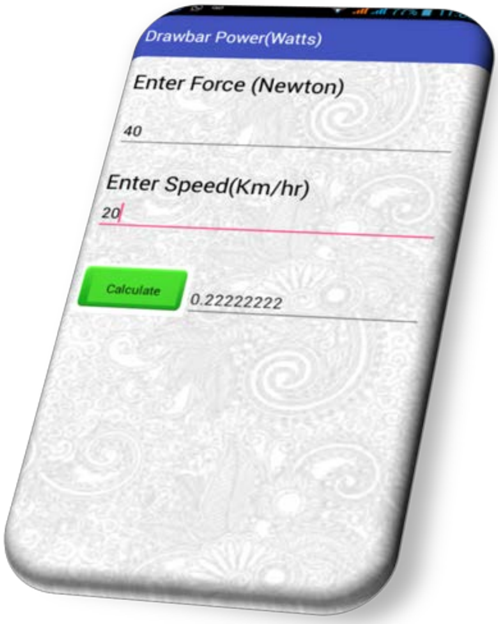
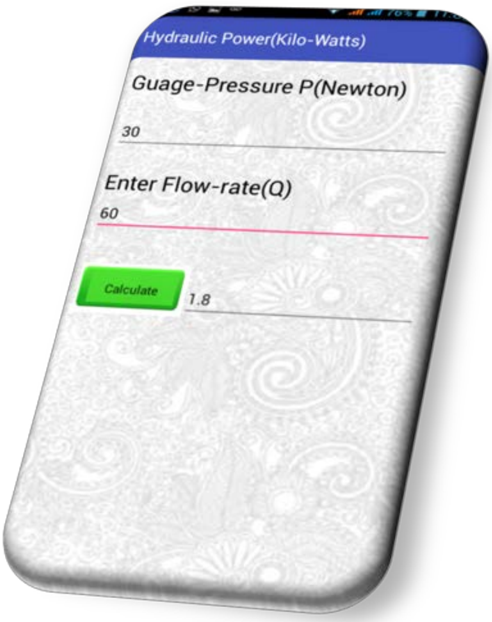


Plate 5: Data Generated

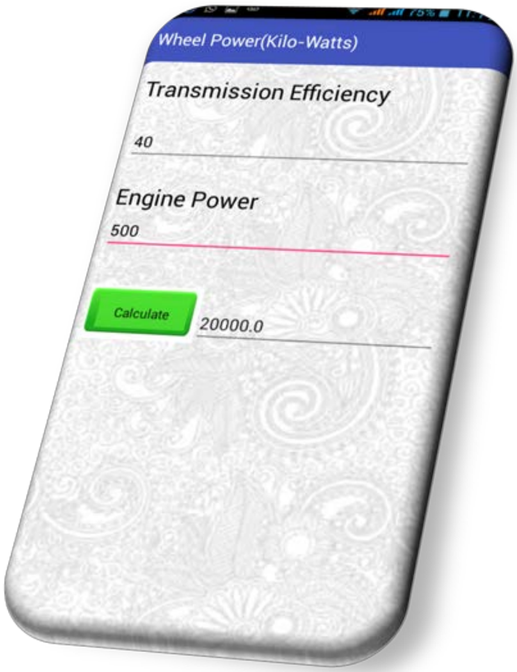
Plate 6 below is the home screen with menu

Plate 6: Menus (Data generated)

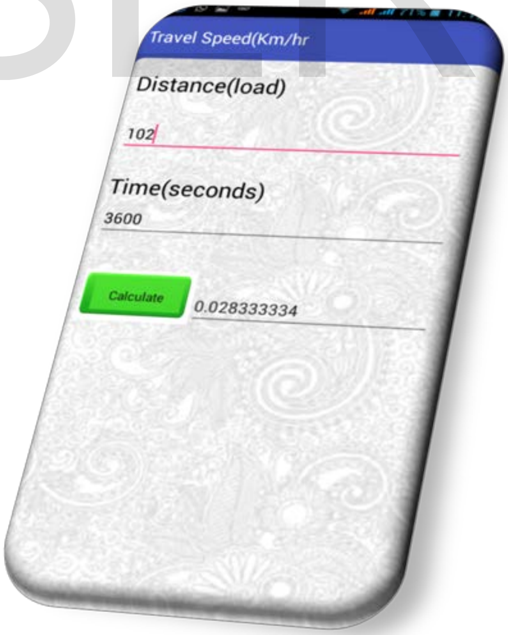





PTO-Power(Kilo-Watts)
Req Drawbar Power(watts)
120
Multiplying Factor
1.5
Calculate
180.0


Wheel Power(Kilo-Watts)
Transmission Efficiency
40
Engine Power
500
Calculate
20000.0


Fuel Consumption(Lit/hr)
Fuel Consumed(gal/litre)
40
Time-Taken(Seconds)
3600
Calculate
0.011111111


Travel Speed(Km/hr
Distance(load)
102
Time(seconds)
3600
Calculate
0.028333334

5.0 Conclusion

From the results obtained after testing the developed model, it may be noted that the model is capable of showing a great validity in matching the optimum tractor maximization equations available under a given field working conditions (soil type and status). The model can calculate optimum implement width and drawbar power, tractive efficiency, travel speed and time required to cover a cultivable area. The model was found to be sensitive to speed and cultivable area variations and not sensitive to purchase prices. From the discussion made it may be concluded that the model could be used as an aid to decision – makers to predict the number of tractors to cover a certain intended area within a time constrain, used to effectively maximize the power output of the tractor or may be adopted for development of a scheduling programme in case of operating multi- machinery units.

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