ecsecc
eastern cape socio economic consultative council

Working Paper Series No. 21

LEVERAGING ICT TO INCREASE PRODUCTIVITY IN THE AGRICULTURAL SECTOR & STIMULATE RURAL DEVELOPMENT

JOSIAH ADEYEMO
MARCH 2017

NEMISA NPC National Electronic Media Institute of South Africa
Moving towards
ICT for Rural Development e-Skills CoLab
iNeSI
WSU Walter Sisulu University

ECSECC Working Paper Series

The ECSECC Working Paper Series was launched as a platform for publishing work in progress in areas broadly aligned with the strategic objectives of the Eastern Cape Socio-Economic Consultative Council. Contributions are invited from ECSECC stakeholder communities as well as independent researchers/writers who share an interest in ECSECC's overarching objectives.

Author: Josiah Adeyemo
Department of Civil Engineering and Surveying
Durban University of Technology
P.O Box 1334, Durban, 4000, South Africa.
E-mail: josiaha@dut.ac.za; adeyemoja@gmail.com
Tel: +27 31 373 2895

Published by ECSECC
Postnet Vincent
P/Bag X9063
Suite No 3025246
Vincent 5247
www.ecsecc.org

ISBN: 978-1-77593-0594

First Published MARCH 2017

CONTENTS

ABSTRACT

Agriculture is an alluring business which should be embraced with the latest technology. This can be done in almost all farming activities. It will reduce labour requirements and ensure safety of humans in otherwise dangerous activities. This paper discusses some applications of information and communication technology in agriculture. These applications will help in rural development by changing the economic status of rural people. Some specific application areas are discussed. These are land management, animal management, crop management, plant disease detection and irrigation management. The study explores some areas where further development and applications are needed especially in South Africa. It is concluded that adaptation of sophisticated information and communication technologies in agriculture can be advantageous in enhancing food security in South Africa, Africa and the world at large. The decrease in labour in many areas of agriculture can be substituted with relevant technologies. The paper is concluded with the list of further research areas in the use of ICT in agriculture especially in South Africa.

Keywords: ICT; food security; rural development; automation; agriculture

1.0 INTRODUCTION

The use of information and communication technology (ICT) in agriculture to enhance productivity and stimulate rural development has always been a fascinating research area. Many areas of agriculture are being computerized to reduce labour requirements, increase productivity and present farming as both lucrative and appealing business. Some activities on the farm pose a lot of health risks. Therefore, there is a need to automate them to reduce human exposures. Appraisal of recent development and adaptation of sophisticated technology in agriculture is essential. Some specific areas of farming are already well suited and adapted for the use of technology. Examples are found in the literature. Other areas are being developed to accommodate the latest ICT to be adapted. It is important to note that the use of ICT in agriculture will not only increase productivity, thereby increasing the economic benefit derived from farming, but also present farming as a modern business which our young generation can embrace. This study discusses many applications of ICT in farming businesses found in the literature.

Different applications in some important aspects of farming are discussed. The paper is organized under the following headings: land management, animal management, crop management, plant disease detection and irrigation management. The paper is concluded with the suggestion for future research.

2.0 ICT APPLICATIONS TO SPECIFIC OPERATIONS

2.1 LAND MANAGEMENT

Agricultural lands should be managed properly to ensure getting maximum economic benefit from them. As lands are cultivated by rural famers, economic viability reduces. Therefore, to boost the economic viability of rural famers, land consolidation is essential. Land consolidation involves land reallocation which can be done by using efficient technology – fast and reliable. In experimenting the use of technology for land reallocation, Uyan, Cay, Inceyol, and Hakli (2015) used two models based on genetic algorithm (GA) and spatial decision support system (SDSS). They found GA-based model to be more efficient than SDSS model in terms of average parcel size, number of parcels and average number of parcels per landowner. These two models, based on computer technology, performed far better than conventional models. Since agricultural sector plays an important role in alleviating poverty of rural subsistence farmers, the use of computer technology will contribute to rural development.

It should be understood that agricultural lands can be transformed into small parcels which have irregular shapes for peasant farmers at subsistence and intermediate commercial farming. This aims to raise sustainable food production for the farmers' survival and economic benefits. The self-dependence, improvement and rural livelihood are the main objectives of any serious government. However, for effective sustainable agriculture and rural development, land fragmentation should be handled with great care. Land fragmentation as defined by Niroula and Thapa (2005) is a state of division of holdings into discrete parcels that are dispersed over a wide area and usually farmed as single units. In South Africa, the loss of land fragmentation in agricultural lands has not been quantified. Apart from economic loss, utilization of machinery and appropriate technology to enhance crop production can be a serious problem for very small fragmented parcels (Uyan et al., 2015). By using land consolidation, land is thus rearranged and properly planned for their different owners using a well-developed technology. This can also be used as an integrated program to develop rural areas or a form of adjustment program. SDSS uses a web-based application tool to monitor and design best application plan, analyse data, extract new knowledge and making informative decision (Tzallas, Katertsidis, & Karvounis, 2014) while genetic algorithms (GAs) are optimization methods using heuristic techniques analogous to Dawning's theory of evolution.

Crop production also presents the problem of farm machinery management. One of the challenges faced is to accurately determine the leave coverage and plant height for machineries to be used on the farm. Plant structural parameters should be accurately retrieved to be able to select best varieties of crops that will consume less water, fertilizer and pesticides with increased yield. This will ensure more profitable farming. At research level, accurate measurements of plant characteristics are essential. At economic farming level, farm machinery use will need these characteristics to perform efficiently. Precision agriculture is in vogue nowadays with minimal assumptions. Many technological methods are thus used to determine accurate measurement of plant characteristics.

LiDAR (Rosell et al., 2009) was used to retrieve plant parameters using 3-dimensional (3D) model which was computed with a light source. Chéné et al. (2012) used a Kinect Microsoft RGB-depth imaging system proposed by Microsoft. Stereovision is another implemented technology used to build plant 3D models by using two view angles. This method uses two cameras which are divided by a fixed baseline distance (He, Hirafuji, & Kozai, 2002; Shrestha, Steward, & Kaspar, 2003). Kise and Zhang (2008) also developed a 3D crop row structure mapping by mounting one stereo camera on a tractor. They used this to estimate the position and height of crop rows to effectively guide a tractor along the right track. Leaf area index can also be retrieved using the camera. Recently, Jay, Rabatel, Hadoux, Moura, and Gorretta (2015) proposed a 3D modelling based method to characterize crop rows. Their model is based on using structure from motion with RGB images acquired by translating a single camera along the row. This technology is accurate, efficient and robust under outdoor conditions and easy to use.

2.2 ANIMAL MANAGEMENT

Livestock management is important to increase profitability of livestock farming. It is extremely important to measure animal locations, activities and behavior all the time. This will make understanding of systemic factors responsible for the growth, reproduction and survival, response to disease and coping mechanisms with environmental conditions possible (Anderson, Estell, & Cibils, 2013; Guillard et al., 2015; Owen-Smith, Fryxell, & Merrill, 2013).

Animal performance and welfare can be effectively optimized by having access to accurate information in real-time. This will ensure timely intervention and management decision taking. These behavioural patterns are however required to be integrated into wireless sensor networks in real-time (Nadimi, Jørgensen, Blanes-Vidal, & Christensen, 2012). These include foraging, resting, ruminative, travelling etc. The steers are required to wear collars which collect data using GPS and motion sensors. This ensures remote monitoring of animal behavior unsupervised.

In another study, a sensing system suitable for integration into an automatic milking system for use on a rotary parlour was developed (Ben Azouz, Esmonde, Corcoran, & O'Callaghan, 2015). Milking may account for 70% of all labour cost on a dairy farm (Ohnstad & Jago, 2007). For dairy farming to be viable, there is a need to reduce these high costs especially with the recent labour shortages in the industry (Dairy-Australia, 2006). Automatic milking systems offer a great solution to milking but difficult to use with grazing. Moreover, it has been established that there is no reduction in labour costs when using AMS and conventional milking processes (Steeneveld, Tauer, Hogeveen, & Lansink, 2012). This results in using rotary milking system that is automated. The manual performance of milking in parlours by operators should also be automated to reduce costs. Therefore, teat sensing system detection is essential. Moreover, real time detection is highly desired to refresh the positions of the teats every 1 to 2 seconds (Ben Azouz et al., 2015). Ben Azouz et al. (2015) therefore, investigated the use of hybrid sensing system for teat detection in automatic milking. This worked well in milking parlour and highly efficient.

Another use of ICT in agriculture is demonstrated in the egg industry by egg production planning. The planning involves improving the number of eggs laid by hens over a period, allocating chicks to replace birds with diminishing laying capacity and minimizing costs to maximize profit generation while meeting customer demand. The use of technology in egg industry to design and build supply chains is inevitable. This presents a lot of complexities in moving chicks of about 17 weeks to a laying unit from pullet-raising farms. They remain there till about 75 weeks and be fed to support egg production (Boonmee, Sethanan, Arnonkijpanich, & Theerakulpisut, 2015) and then slaughtered. Boonmee et al. (2015) worked on allocation of pullets to hen houses. This is to minimize the total cost given some economic constraints and different demand volumes in the planning. They considered three main components of total cost which are cost of farm utilization, transportation cost from pullet farm to hen farms and loss from mixing hens at different ages in the same hen houses. Growing neural gas (GNG) algorithm was used to solve the problem. A new DSS was proposed. The results obtained showed that the algorithm provided better total cost values than previous costs.

In a poultry house, optimum climatic condition can play a significant role in ensuring low mortality rate of birds. Maintenance of high efficient atmospheric condition under changing climate conditions requires advanced control systems (Soldatos, Arvanitis, Daskalov, Pasgianos, & Sigrimis, 2005). Unnecessary energy costs for heating and cooling system for poultry house can be avoided. Mirzaee-Ghaleh, Omid, Keyhani, and Dalvand (2015) developed a fuzzy system that can control the important parameters including temperature, relative humidity, CO_2 and NH_3 in a poultry house with high accuracy.

2.3 PLANT DISEASE DETECTION

In crop production, ability to quickly detect diseases can save other crops from infection. This can prevent loss in farming. Some diseases are identified visually. In a large farm, this may be impossible to detect by human eyes. There can also be human errors. Therefore, the use of ICT in early disease identification is essential. A critical example of such disease can be found in citrus which is called citrus greening. This disease can cause enormous loss to family. It can result to early fruit drop causing loss to citrus production. Yellowing of leaf is also a symptom of citrus greening. These symptoms can be used for the disease diagnosis. While professional inspection can be efficient, a laser-induced fluorescence (LIF) spectroscopy method can be employed to discriminate water-stressed and citrus canker- infected citrus leaves from healthy ones (Marcassa et al., 2006).

A. Pourreza, Lee, Raveh, Ehsani, and Etxeberria (2014) developed a customized image acquisition system which can highlight an increased level of starch accumulation in citrus greening symptomatic leaves. They also improved the performance of this method by implementing a completely new sensing device (Alireza Pourreza, Lee, Ehsani, Schueller, & Raveh, 2015). They therefore developed a vision sensor for real-time in-field citrus greening detection, add on-the-go diagnosis capacity to the sensor, improve citrus greening detection accuracy and developed a simpler and more robust identification algorithm. Technology can also be used to identify pest in some fruits. An example is the study by Boniecki et al. (2015) where artificial neural networks (ANNs) was used as a tool for classification, designed to identify apple orchard pests. Since current methods of pest identification are primarily based on their visual identification by man, they proposed the use of ICT to identify pests. The characteristics used for the identification include colour, shape and their bionomy or method of feeding. This, therefore, allows the automation of the identification process. The automation will eliminate the human associated problems like subjectivity of assessment, fatigue and other factors generating errors in human observation (Nadimi et al., 2012). The use of artificial intelligence in identification of pests is feasible and advisable. Boniecki et al. (2015) therefore studied the possibility of using ANN for pest identification. The obtained results support the use of ANN as effective tool that supports the process of identifying pests in apple orchards.

Use of pesticides is an economic burden for farmers, pollution to the environment and health hazards for animals and humans. Successful crop production should ensure safety, effective and efficient pest control operation for the success of crop production (Perez-Ruiz, Agüera, Gil, & Slaughter, 2011). Therefore, many researchers are working on using autonomous vehicles and robotic technology in bio-production systems to optimize complex agricultural operations related to weed management (Pérez-Ruiz et al., 2015). We now have weed/pest and crop sensors thanks to overcoming technological challenges in information and communication systems. Pérez-Ruiz et al. (2015) presented the development and preliminary results for new crop protection implements mounted on an autonomous tractor. This is used for pest management for both agriculture and forestry in both chemical and physical domains (i.e. mechanical and thermal).

2.4 CROP MANAGEMENT

Herrero-Huerta, González-Aguilera, Rodriguez-Gonzalvez, and Hernández-López (2015) developed a work-flow to determine vineyard productivity. Their innovative way is flexible and simple. The method for data acquisition and automation results in low cost sensors. They used computer vision and close range photogrammetry to determine yield. Vineyard productivity was determined using different algorithms and techniques. Volume, mass and number of berries per bunch are the parameters estimated using their developed algorithms and techniques. Their techniques were benchmarked using laboratory tests. This methodology stands the test of time and very effective. This methodology was used to predict the results and planning the vintage optimally by adapting PW software tool. The merits of PW are process automation, sufficient quality to generate dense resolution models equivalent to the pixel size of the image and low cost and ease of use. Weather can pose a serious threat to the reliability of the equipment used.

Agricultural product supply, especially to the market and industries is very important. Supply chain management is highly desired in perishable produce. This is to prevent spoilage before use and reduction in the selling price to the end users. This problem can be solved by solving the complex problem of harvesting scheduling. There are a lot of factors responsible for harvest scheduling of these are biological characteristics which are uncertain and variable, production variation like grower's skill and the number of farms involved in the scheduling plan (Thuankaewsing, Khamjan, Piewthongngam, & Pathumnakul, 2015). In solving the harvesting scheduling problem of sugar cane, Thuankaewsing et al. (2015) proposed a small scale with highly different environments and constraints. They developed a flexible yield estimation model that account for the heterogeneous conditions in the fields. ANN is applied to estimate cane yield over a harvest season. Then the estimated yield under the condition of fair benefits for all the growers in the group was maximized. The results showed that there are potential benefits from the model.

Evaluation of near infrared reflectance (NIR) spectroscopy to determine oil content in whole corn was studied by (Fassio, Restaino, & Cozzolino, 2015). Modern agriculture thrives by assisting farmers, researchers and plant scientists to document fingerprint composition, physiological or biochemical properties (White et al., 2012). These properties will help to develop appropriate technology for crop production advancement. Oil content in corn is important to farmers. Its determination is invaluable for monitoring of success of selective breeding and transgenic engineering programs focused on increasing oil content in a commercial crop (Kotyka et al., 2005). The study of Fassio et al. (2015) concluded that NIR spectroscopy is a starter in developing a more robust and acceptable models for oil content determination in corn samples.

2.5 IRRIGATION MANAGEMENT

Irrigation consumes a lot of water but increases productivity. Unfortunately, it is difficult to ascertain when to irrigate priori with recent weather information. Therefore, real-time irrigation of crops is essential to save water and increase productivity. Farmers need a handy instrument to help informing them of right time to irrigate in real time. Bartlett, Andales,

Arabi, and Bauder (2015) reported an online evapotranspiration based irrigation scheduling tool called water irrigation scheduling for efficient application (WISE). They developed a smartphone app that allows users to quickly view their soil moisture deficit, weather measurements and the ability to input applied irrigation amount into WISE. As long as there is cellular data network, farmers and scientists will benefit from this app. This is a step ahead in ensuring the use of ICT in allowing irrigators to better utilize water resources.
In water distribution, application of water uniformly across the field using sprinkler irrigation system is important. Mathematical models were used to simulate droplet dynamics and evaporation was proposed by Li, Bai, and Yan (2015). The developed software can predict the water distribution of an individual sprinkler with relatively high accuracy under different conditions.

3.0 CONCLUSION

This study has shown the importance of ICT in developing agriculture especially in South Africa. Several adaptations of ICT to farming operations are demonstrated as found in the literature recently. As modern technologies are evolving and used in other areas, agriculture can also be a beneficiary of a changing world. As such, farming will be both lucrative and alluring business. Rural development can be stimulated by improving living conditions of rural people through increased yield. The economic status of rural people can be improved by generating more profit from their farming business through better practices. It has been established that many tedious activities on the farm can be done efficiently and effectively with the introduction of ICT.

3.1 SUGGESTION FOR FURTHER STUDIES

South Africa is joining the rest of the world by embracing ICT in farming to increase productivity. However, these important areas are suggested for future research in South Africa:

- Estimation of South African agricultural land lost to fragmentation.
- Use of ICT for land allocation to peasant and commercial farmers to reduce loss and improve farming activities.
- Use of sensors to determine plant structural characteristics to enhance use of machinery for farming operations.
- Increase the use of automation in animal farming in South Africa with emphasis on cattle milking using sensors and identification of teats.
- Behavioural analysis of animals using sheers worn by animals and sending collected data in real time.
- Use of artificial neural networks (ANNs) for supply chain in harvest scheduling. This will ensure the marketability of agricultural products.
- Use of ANN for real time applications in agriculture.
- The use of DSS and technology for disease detection in plants and animals especially in real time.
- Fuzzy logic controllers to maintain climate in an environment especially in poultry
- The use of motion sensors in disease control in plants

REFERENCES

Anderson, D. M., Estell, R. E., & Cibils, A. F. (2013). Spatiotemporal cattle data—a plea for protocol standardization. Positioning, 4, 115-136.
Bartlett, A. C., Andales, A. A., Arabi, M., & Bauder, T. A. (2015). A smartphone app to extend use of a cloud-based irrigation scheduling tool. Computers and Electronics in Agriculture, 111(0), 127-130. doi: http://dx.doi.org/10.1016/j.compag.2014.12.021
Ben Azouz, A., Esmonde, H., Corcoran, B., & O'Callaghan, E. (2015). Development of a teat sensing system for robotic milking by combining thermal imaging and stereovision technique.Computers and Electronics in Agriculture, 110(0), 162-170. doi: http://dx.doi.org/10.1016/j.compag.2014.11.004
Boniecki, P., Koszela, K., Piekarska-Boniecka, H., Weres, J., Zaborowicz, M., Kujawa, S., . . . Raba, B. (2015). Neural identification of selected apple pests. Computers and Electronics in Agriculture, 110(0), 9-16. doi: http://dx.doi.org/10.1016/j.compag.2014.09.013
Boonmee, A., Sethanan, K., Arnonkijpanich, B., & Theerakulpisut, S. (2015). Minimizing the total cost of hen allocation to poultry farms using hybrid Growing Neural Gas approach. Computers and Electronics in Agriculture, 110(0), 27-35. doi: http://dx.doi.org/10.1016/j.compag.2014.10.006
Chéné, Y., Rousseau, D., Lucidarme, P., Bertheloot, J., Caffier, V., Morel, P., . . . Chapeau-Blondeau, F. (2012). On the use of depth camera for 3D phenotyping of entire plants. Comput. Electron. Agric., 82, 122-127.
Dairy-Australia. (2006). Dairy situation and outlook: report to the Australian dairy industry. Dairy Australia, Melbourne, Australia.
Fassio, A. S., Restaino, E. A., & Cozzolino, D. (2015). Determination of oil content in whole corn (Zea mays L.) seeds by means of near infrared reflectance spectroscopy. Computers and Electronics in Agriculture, 110(0), 171-175. doi: http://dx.doi.org/10.1016/j.compag.2014.11.015
Guillard, V., Buche, P., Destercke, S., Tamani, N., Croitoru, M., Menut, L., . . . Gontard, N. (2015). A Decision Support System to design modified atmosphere packaging for fresh produce based on a bipolar flexible querying approach. Computers and Electronics in Agriculture, 111(0), 131-139. doi: http://dx.doi.org/10.1016/j.compag.2014.12.010
He, D., Hirafuji, M., & Kozai, T. (2002). Growth prediction of a transplant population using artificial neural networks combined with image analysis. In: Third Asian Conference for Information Technology in Agriculture (AFITA 2002), Beijing, China, 266 - 271. Herrero-Huerta, M., González-Aguilera, D., Rodriguez-Gonzalvez, P., & Hernández-López, D. (2015). Vineyard yield estimation by automatic 3D bunch modelling in field conditions. Computers and Electronics in Agriculture, 110(0), 17-26. doi: http://dx.doi.org/10.1016/j.compag.2014.10.003
Jay, S., Rabatel, G., Hadoux, X., Moura, D., & Gorretta, N. (2015). In-field crop row phenotyping from 3D modeling performed using Structure from Motion. Computers and Electronics in Agriculture, 110(0), 70-77. doi: http://dx.doi.org/10.1016/j.compag.2014.09.021
Kise, M., & Zhang, Q. (2008). Development of a stereovision sensing system for 3D crop row structure mapping and tractor guidance. Biosyst. Eng., 101, 191–198. Kotyka, J., J., Pagela, M. D., Deppermannb, K. L., Collettib, R. F., Hoffmanc, N. G., . . . Ackermand, J. J. H. (2005). High-throughput determination of oil content in corn kernels using nuclear magnetic resonance imaging. JAOCS, 82.
Li, Y., Bai, G., & Yan, H. (2015). Development and validation of a modified model to simulate the sprinkler water distribution. Computers and Electronics in Agriculture, 111(0), 38-47. doi: http://dx.doi.org/10.1016/j.compag.2014.12.003
Marcassa, L., Gasparoto, M., Belasque Jr., J., Lins, E., Nunes, F. D., & Bagnato, V. (2006). Fluorescence spectroscopy applied to orange trees. Laser Phys., 16, 884-888.
Mirzaee-Ghaleh, E., Omid, M., Keyhani, A., & Dalvand, M. J. (2015). Comparison of fuzzy and on/off controllers for winter season indoor climate management in a model poultry house. Computers and Electronics in Agriculture, 110(0), 187-195. doi: http://dx.doi.org/10.1016/j.compag.2014.11.017
Nadimi, E. S., Jørgensen, R. N., Blanes-Vidal, V., & Christensen, S. (2012). Monitoring and classifying animal behavior using ZigBee-based mobile ad hoc wireless sensor networks and artificial neural networks. Comput. Electron. Agri., 82, 44-54.
Niroula, G. S., & Thapa, G. B. (2005). Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. Land Use Policy, 22(4), 358 - 372. Ohnstad, I., & Jago, J. (2007). The Development of Automatic Cup Attachment Technology for New Zealand Dairy Farms. – A Feasibility Study. Report to Dairy InSight, Wellington, New Zealand.
Owen-Smith, N., Fryxell, J. M., & Merrill, E. H. (2013). Foraging theory upscaled: the behavioural ecology of herbivore movement. Philos. Trans. R. Soc. B, 365, 2267-2278.
Perez-Ruiz, M., Agüera, J., Gil, J. A., & Slaughter, D. C. (2011). Optimization of agrochemical application in olive groves based on positioning sensor. Precision Agric., 12, 564-575.
Pérez-Ruiz, M., Gonzalez-de-Santos, P., Ribeiro, A., Fernandez-Quintanilla, C., Peruzzi, A., Vieri, M., . . . Agüera, J. (2015). Highlights and preliminary results for autonomous crop protection. Computers and Electronics in Agriculture, 110(0), 150-161. doi: http://dx.doi.org/10.1016/j.compag.2014.11.010
Pourreza, A., Lee, W. S., Ehsani, R., Schueller, J. K., & Raveh, E. (2015). An optimum method for real-time in-field detection of Huanglongbing disease using a vision sensor. Computers and Electronics in Agriculture, 110(0), 221-232. doi: http://dx.doi.org/10.1016/j.compag.2014.11.021
Pourreza, A., Lee, W. S., Raveh, E., Ehsani, R., & Etxeberria, E. (2014). Citrus Huanglongbing detection using narrow-band imaging and polarized illumination. Trans. ASABE, 57, 259-272.
Rosell, J. R., Llorens, J., Sanz, R., Arnó, J., Ribes-Dasi, M., Masip, J., . . . Palacín, J. (2009). Obtaining the three-dimensional structure of tree orchards from remote 2D terrestrial LIDAR scanning. Agric. Forest Meteorol., 149, 1505-1515.
Shrestha, D., Steward, B., & Kaspar, T. (2003). Determination of early stage corn plant height using stereo-vision. In: 6th International Conference on Precision Agriculture and Other Precision Resources Management, Minneapolis, MN, USA, 1382–1394.
Soldatos, A. G., Arvanitis, K. G., Daskalov, P. I., Pasgianos, G. D., & Sigrimis, N. A. (2005). Nonlinear robust temperature–humidity control in livestock buildings. Comput. Electron. Agri., 49, 357–376.
Steeneveld, W., Tauer, L. W., Hogeveen, H., & Lansink, A. G. J. M. O. (2012). Comparing technical efficiency of farms with an automatic milking system and a conventional milking system. J. Dairy Sci., 95(12), 7391-7398.
Thuankaewsing, S., Khamjan, S., Piewthongngam, K., & Pathumnakul, S. (2015). Harvest scheduling algorithm to equalize supplier benefits: A case study from the Thai sugar cane industry. Computers and Electronics in Agriculture, 110(0), 42-55. doi: http://dx.doi.org/10.1016/j.compag.2014.10.005
Tzallas, A. T., Katertsidis, N. S., & Karvounis, E. C. (2014). Modeling and simulation of speed selection on left ventricular assist devices. Comput. Biol. Med., 51, 128 - 139.
Uyan, M., Cay, T., Inceyol, Y., & Hakli, H. (2015). Comparison of designed different land reallocation models in land consolidation: A case study in Konya/Turkey. Computers and Electronics in Agriculture, 110(0), 249-258. doi: http://dx.doi.org/10.1016/j.compag.2014.11.022
White, J. W., Andrade-Sanchez, P., Gore, M. A., Bronson, K. F., Coffelt, T. A., Conley, M. M., . . . Wang, G. (2012). Field-based phenomics for plant genetics research. Field Crops Res., 133, 10

ecsecc
eastern cape socio economic consultative council

12 Glouchester Road, Vincent, East London, 5217
Postnet Vincent, Private Bag X9063, Suite 302, Vincent, 5247

+27 (0)43 701 3400
+27 (0)43 701 3415
info@ecsecc.org
www.ecsecc.org