An Intelligent Agri-Information Dissemination Framework: An Information Extraction Mechanism

Qanita Ahmad, Imran Sarwar

Al-Khawarizmi Institute of Computer Sciences
University of Engineering and Technology
Lahore, Pakistan
{qanita.ahmad,Imran.sarwar }@kics.edu.pk

***Abstract*—Farmers, specifically of developing countries, face problems like soil attrition, yield losses, reduced market prices, increased pesticides costs and economic barriers. These problems prevent these cultivators from adopting modern farming strategies and hence render them vulnerable. However, these farmers can use pre-hand information to make informed decisions with respect to all agricultural operation. We propose an Agriculture Information System (Agr-IS) based on ICTs and e-government infrastructure for the benefit of rural farmers by educating them on different aspects of Sustainable Agriculture (SA). The core functionality of proposed information system is supported by an intelligent Agro-DSS which receives information from various agencies and dispatches the relevant information to the lower end farmers. Agro-DSS works in collaboration with Agr-IS, various other open source software (like Asterisk server), and other information gathering infrastructure for the dissemination of up-to-date agricultural information in a readily accessible and easily understood form, to farmers, agricultural researchers, and advisers. With a diverse biophysical and socio-economic data and knowledge, the presented information gathering and dissemination infrastructure will help reduce the uncertainty and improve decision making process by providing access to data, procedures and analytical capability.**

Keywords-Sustainable Agriculture, Intelligent Systems, e-Government, SOA

I. INTRODUCTION (HEADING 1)

In 2007, the United Nations revealed that at least 50 percent of the world's population is living in metropolitan areas. Despite of urbanization at such masses, 75% of the world's poor live rurally, and agriculture remains the largest single contributor to their livelihoods [21]. Agricultural development is therefore of vital importance to the alleviation of poverty in the developing world. While the principles of agricultural development are well known, there is new buzz-word "sustainable agriculture" which means an integrated system of plant and animal production practices having a site-specific application that will, over the long term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate; where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; enhance the quality of life for farmers and society as a whole."

Along-side to the information dissemination mechanism, there is a need for an intelligent system and automated governmental involvement to manage the above mentioned complexities involved within the umbrella of sustainable agricultural. Such intelligent system is required to determine what advice to be offered to farmers who have to decide what action to take based on it. The intelligence module makes informed decision based on proper information about liabilities and the latest technological trends prevalent in the specific domain. In order to give better advices to the lower end farmers, the data requirements of the intelligent system include weather inputs (daily maximum and minimum temperature, rainfall and solar radiation), soils classification, and crop management practices (variety, row spacing, plant population, fertilizer and irrigation application dates and amounts). Such extensive knowledge acquisition can be done by employing location based services of the mobile telephony and Geographical Information Systems (GIS), scraping the information from the internet or through other data perception services established locally to assess the terrain conditions.

Our proposed solution addresses, among others, the following objectives:

- Strengthening information dissemination between Government and rural farmers, regardless of their location in the country
- Provisioning of better quality agriculture to the rural farmers–preferably through mass agri-information alerts in the form of SMSs
- Improving crop yield by reducing the time spent upon spreading manual information and thus aiming for self-sufficiency in food requirement
- Better and timely nation-wide agricultural administrative control

We believe that the new country-wide Intelligent Agri-information Dissemination Framework, along with other state-of-the-art features, should provide dependable mobile network based infrastructure to disseminate information among all

constituent Government departments and farmers. The architecture, moreover, should offer an extensible design that can self-configure and facilitate future Agri-e-services to be easily integrated in it.

II. RELATED WORK

A. *Texting for Agro-informatics*

Agricultural systems remain the principal land-using sectors in an agricultural country of Pakistan where the main source of income depends on the cultivation of lands. There is a dire need for a paradigm shift from solely encouraging increased agricultural production, to underpin food security and increase rural prosperity, towards multi-functional or post-productive rural land use and sustainable development. Prosperity of the farming sector is thus increasingly to be balanced with food safety, environmental protection and sustainable development of the rural community as a whole [13, 14, 15, 18].

Specifically texting, from the mobile media, can be used to stream-line information as it is the most ubiquitous form of communication outside voice calls. The impact of cell phone use on environments is very much reduced when text-based messages (SMS) instead of audio calls are used. A major advantage of SMS lies in the fact that messages can be sent and received in a highly unobtrusive way [13]. In addition, SMS is compatible with conditions where phone calls are totally impossible: either (a) with high levels of noise or (b) when total silence is to be maintained (in the buzz of tractors or thrashers in fields) [13]. Figure1 illustrates an infrastructure for information dissemination over mobile networks.

B. *An Agricultural DSS for Informed Decision Making*

Decision support systems can assist agriculturists in better assessment of the crop and by integrating the relevant information into a more useable form, altering production systems, enhancing management skills, and reducing costs of production [20]. Nonetheless, agricultural production decision-making is quite complex. This is due, in part, to the increased competition caused by the globalization of agriculture and the need to adopt more sustainable farming practices. And in part due to the scarcity of the appropriate information for the crop and farm assessment to analyze the situation in entirety to make precise decision, especially in the underdeveloped countries. These issues greatly increase the need to manage the way information is combined and used when making decisions [19, 20].

A number of agricultural DSS has been implemented to cater different aspects of incorporation of sustainability in farming and crop management. In [17], a working beta version of Apollo, a prototype decision support system, is developed to assist researchers in using the Decision Support System for Agro technology Transfer (DSSAT) crop growth models to

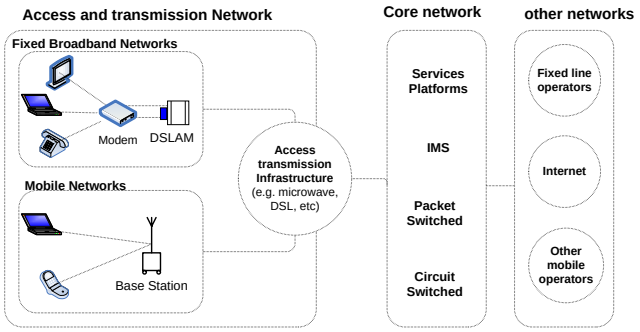

Figure 1. Texting for information- basic infrastructure

analyze precision farming datasets. GPFARM [30, 31] is another decision support system (DSS) software package currently being developed by the USDA-ARS Great Plains Systems Research Unit. The primary goal of the Great Plains Framework for Agricultural Resource Management (GPFARM) DSS is to provide farmers and ranchers with a strategic tool to evaluate long-term effects of management and resource allocation on economic and environmental sustainability.

Despite the potential benefits, a review of the literature suggests that the uptake of DSS technology by primary producers has been limited [24, 29]. The uptake of DSS by farmers has been slow and various factors contributing to this reluctance include fear of using computers, time constraints, poor marketing, complexity, lack of local relevance, lack of end-user involvement, and mismatched objectives between developers and users. The future prospects for the development of DSS, especially for agricultural purposes, were regarded to be poor. However, a few improvements can be made in decision support systems to be broadly acknowledged by farmers. Any successful DSS needs to address widespread problems: they need to be location specific, and gain strong support from initial users. They also need to be simple to use, relevant, effective, low cost, and user friendly and it is most likely that farmers would have been involved in their development. Using text messaging as a mechanism to streamline information at both ends, would greatly increase augment the usage of intelligent modules in agricultural domain. Not just being cost effective and user-friendly, a dedicated infra-structure can put together for bi-directional information structure that would help the lower end farmers as well as the researchers for better crop and farm socio-economic and research aspects.

C. *Information Gathering Mechanism forAgr-IS*

Another key component required by virtually all information discovery system infrastructures accessing cyberspace (i.e., the Internet) is an extractor that systematically crawls the Internet to gather diverse types of data sources and transforms or summarizes them into a single, uniform, meta-

data format. This format generally reflects the format found in the system used by the person requesting the information. [33, 34]

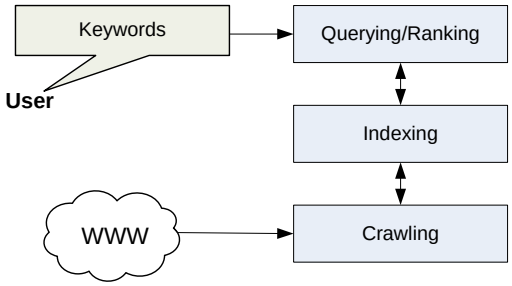

Figure 2. A simplistic mechanism for web crawling

The indexing mechanism helps to find the relevant information to respond to user query as quickly as possible. It is analogous to cataloging. Indexing uses techniques like parsing and hashing to extract the link and save the knowledge in an efficient manner which enables the timely retrieval of requested information against user queries.

Web crawlers are simple programs that locate and gather information from the web. They recursively follow hyperlinks present in known document to find other document. The usual starting points are lists of heavily used servers and very popular pages. In this manner, the keywords from the queries posted by the end users are searched over the internet to find relevant details which will then be presented to Agro-DSS to make proper replies for the user queries.

III. BASIC INFRASTRUCTURE

As previously described by the authors [25], this section will discuss the feasibility of mobile phone hardware to be used in the rural conditions. An infrastructure is yet to be proposed that addresses the limitations at the higher end for the bidirectional communication. We propose mobile information service architecture for the development of the basis of sustainable agriculture that works in conjunction with previously described Agro-DSS for making informed decisions. Supplemented by Asterisk based SMS Gateway designed to operate 24/7 which requires little support and provides extremely high capacity (over 300 SMS / second on a standard Intel P4 3Ghz CPU)[32].

Not being constrained by an installed application base or pre-existing assumptions about the delivery of web-based services, we have started from first principles to develop an architecture that is uniquely suited to rural device, user and infrastructure constraints.

A. Service and Content Delivery Requirements

There are various components to the release of the anticipated system. The information and services provided have to inherently be shared between several different organizations in partnership. There are five key delivery components which are concisely stated here:

1) Text messaging Gateway- the gateway receives requests from subscribers in the form of text messages; it queries the knowledge base and responds with appropriate replies from the decision support system. Using text-to-speech translation module, the gateway converts these responses to respective voice messages. Using its Interactive Voice Response (IVR) system, these voice messages can be disseminated to the end user in order to satisfy his query. This gateway also manages several user groups and their service (SMS, voice mail, e-mail etc) provision settings.

2) Administrative Website- The program requires a web interface for participants for registration and dissemination of information.

3) Text Communication Network- Other telecommunications companies will provide the interface with the gateway service that allows text messages to be sent to their customers.

4) Agro-Decision Support System- Based upon the location of the mobile subscriber, the decision support module responds to the user queries and/or issue notifications with highly relevant information. Agro-DSS consists of a number of components: a data gathering and management system, a knowledge engine, and an inference engine.

5) Real Time Data Collection Services- Agro-DSS is backed with an extensive set of real time data gathering services to capture data about the weather and geographic information from authenticated resources. These services scrap information from national agricultural research portals and other climatic information to better assess the situation.

B. Proposed Features

The Agro-Alert Text Messaging Solution, as illustrated in figure 5, is anticipated to be compatible with any mobile device and carrier in Pakistan. As discussed in [5] the solution must provide the following features and benefits:

1) Self-Managed and Administered Web-based Interface: This will allow user to log in to a secure online account management interface, type a message and instantly broadcast important, time-sensitive alerts to thousands of people within the community.

2) Agr-IS: System to manage the whole set of issues regarding agricultural information and data collection services.

3) Agri-DSS: Intelligent system to make informed decisions based upon the knowledge provided by the Agr-IS.

4) Subscriber and Group Management: This will allow users to upload mobile numbers and create multiple groups utilizing a group management interface. Messages can be sent to both groups and individual users.

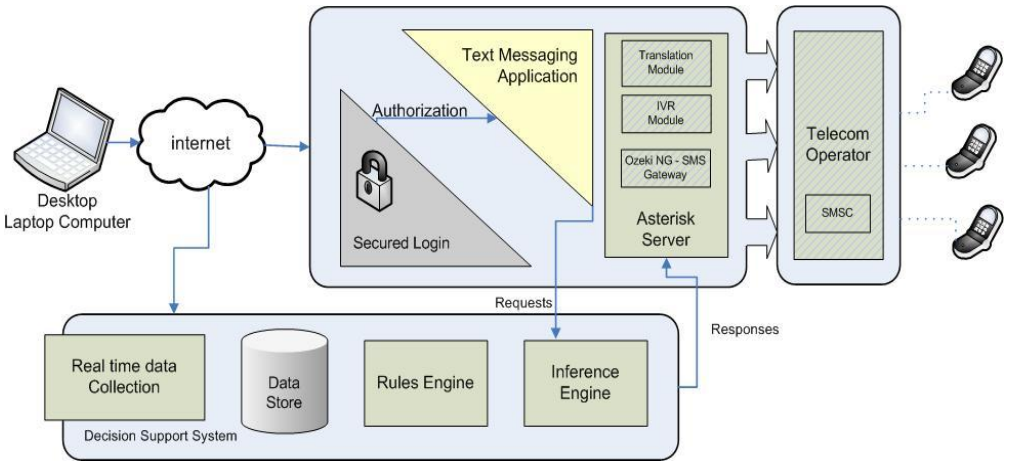

Figure 3. Basic Infrastructure for Agricultural Information System (Agr-IS)

5) Two-Way Messaging Capability: Facilitate recipients to respond via two-way messaging, the queries will be instantly replied.

6) Interactive Voice Response (IVR). This feature will respond to a certain individual based on a query or even broadcast a message to a group of remote end users as a public address system. The feature will greatly facilitate the utterly illiterate mazaraas.

7) Festival: This is a text-to-speech conversion application that can be used along with Asterisk. This feature converts the text message to voice. The text message could be the query by user or response to some particular query by the system. The resulting voice could be sent to an individual or broadcast to a group of subscribers.

IV. AGRO-ALERT FOR FARMERS, THE STRATEGY

The increased acceptance of mobile phones and use of SMS can be utilized to reach wider groups of people while maintaining quickness and accuracy in messaging, a trend that is already becoming reality. With a wide mobile phone usage, there is a need to evaluate and implement nation-wide text messaging in order to disseminate important information to thousands of people quickly. In this paper we propose a system for general awareness for sustainable agriculture based on SMS using mobile network.

Based upon the urgency of the information to be disseminated, the decision system marks an SMS into different categories that might include, but are not limited to the following; i) Information: the relevant information about a certain topic, for example how the crop rotation strategies make an impact on the fertility of the soil in a certain geographic area, ii) Notice: to notify the availability of certain information, launching of new ecological friendly pesticide and the market place information, iii) Warning: to caution the user about high risk climatic or environmental catastrophes like the weather forecasts of heavy rains and the measure to be taken to minimize the impacts, iv) Alarm: to notify the receiver of a certain event which demands an action on his behalf like weekly pesticide sprays of vaccination for livestock, v) Query Resolution: A sequence of requests and responds between user and the low end farmer for example a bidding portal for the crops raisers which requires bidirectional inputs.

Our proposed solution can be accessed and managed, administratively, only through a secure, password-protected web interface for the administrative usage. In addition to one-way alert notification, the system will enable recipients to respond via two-way messaging, and replies will be instantly delivered. The solution will also feature full redundancy for text message delivery and remote back-up in the case of a local system failure.

A. *Agricultural Decision Support System (Agro-DSS)*

For the purpose of this paper, the definition of DSS is restricted to computer-based tools, developed to provide analysis and advice to decision makers. For Agro-DSS the emphasis is on support, since people make decisions and software at best only assists and not controls automatically. Agro-DSS is not only a software tool but also a knowledge repository for sustainable agricultural which facilities to communicate or interpret the relevant outputs to possible stakeholders [15] as shown in the figure 3.

B. *Real Time Data Collection Services*

Many management decisions in modern farming require up-to-date and local information, for example regarding weather forecasts and regional recordings of crop diseases and pests. In Pakistan the organizations like PARC[26], Pakistan Agricultural Research Council has been set up for the development of Animal Sciences, Crop Sciences, Horticulture, Farm Machinery, Natural Resources, Social Sciences, and Agricultural Informatics which cover different aspects of sustainable agriculture. Some of the agricultural map maintained by PARC that are of great help for establishment of agricultural information system in Pakistan are: 1) Agro-Ecological Zones of Pakistan, 2) Cropping Patterns, 3) Aridity Classes, 4) Crop Growth Classes of Pakistan. PARC works in collaboration with NARC [27] which is involved in research thrusts like: (A) Productivity Improvement (B) High Value Agriculture (C) Post-harvest and value Chain Technologies: (D) Sustainable Resources Use and Environment Protection.

These and other organization set up locally can work in collaboration with the online weather and climatic forecast portals to provide real time information to Agro-DSS for informed decision making.

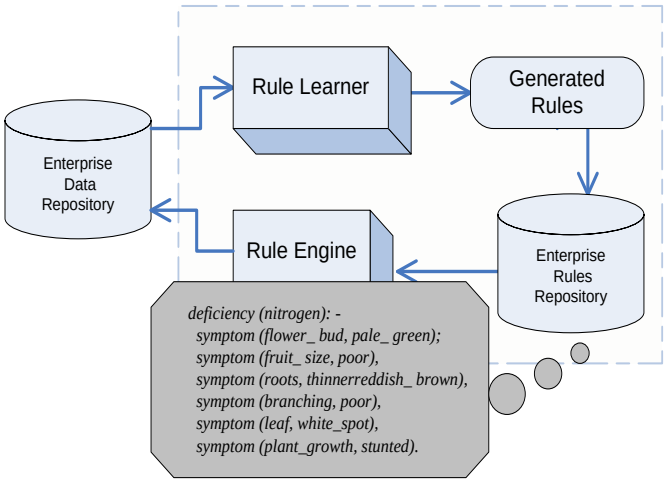

Figure 4. Rules Engine for Agro Alert

We present a simplistic infrastructure for the information gathering through various sources, as shown in the figure 5, for the benefit of the farmers. When a query is presented to the system, the knowledge engine it checks its internal knowledge base for the relevant information. However the content which is not available in the knowledge base, a simple query is passed on to the web crawler. The raw information extracted from the internet is then fed to knowledge extraction module to convert the information into rules as specified in the Rules Engine. The Knowledge Extraction module works in close collaboration with the Language models and predefined ontologies as lexicon to facilitate the parsing of the retrieved input. It is the duty of the knowledge engine to retrieve the information and to generate a proper response to be dispatched to the end user.

The real time information like temperature and weather forecasts, however, are updated on regular basis from the internet or other information providing agencies.

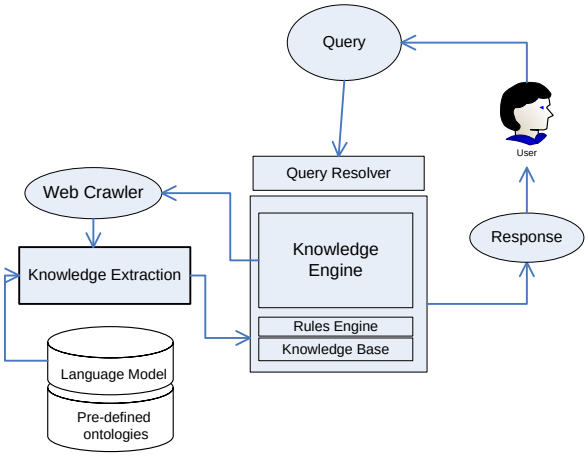

Figure 5. Proposed information gatherer for the texting infrasturcute

C. *Asterisk for Internet Telephony*

Asterisk is open source software that can be used to realize the telecommunications modules working in collaboration with Agro-DSS to streamline information to the subscribers. Along-with fulfilling the functionality of a software private branch exchange (PBX); it can be deployed in many creative ways and is flexible enough to cover as many areas of the texting application working in conjunction with other modules to realize the agricultural information system for rural areas.

For the proliferation of electronic messages across the nation wide rural farmers; the need to provide farmers, cultivators, and partners with consistent information; the desire to better equip information lower end farmers with meaningful information to drive informed decisions; and the mandate to control costs without sacrificing application availability, security, or reliability. The Ozeki NG[32] SMS Gateway, as shown in figure 4, has been designed to help enterprises address these challenges in mobile communication. The Ozeki NG SMS Gateway is a software product that will help maximize the productivity of IT by reducing the complexity of creating, deploying, and managing mobile communication applications. It empowers developers through a rich, flexible, modern development environment for creating secure, high performance solutions based on the SMS technology in order to help establish farmers communities for the dissemination of relevant information to the specifies needs of agriculturist on as and when required basis. Major features that support the use asterisk based solutions for the implementation of such a module are: (a) High capacity. Up to 500 SMS/second (on IPSMS connections), (b) Support for long (multipart) messages, (c) Message Waiting Indication Support, to enable Voice mail waiting or Fax waiting indication on cell phones, (d) support for local and international recipient number formats.

Asterisk can receive a phone call or SMS and, based on the relevant attributes, it can decide whether to route the call to one user, a specific group of users, to mailbox or call record. This feature of Asterisk will greatly help the in the management of subscriber groups and broadcasting the electronic messages on the groups. Using its rich interactive voice response (IVR) features, we can respond the user by an audio message as well. Asterisk can provide 24 hours service, allowing to play back files, read text, and retrieve information from a database. Because Asterisk's IVR is distributed, so we can send this retrieved data in text or audio form to the audience, whether, an individual or group. Festival is a text-to-speech application that is callable from within Asterisk. By using Festival text-to-speech server we can transfer text into spoken words. In this manner we shall exploit several features of Asterisk to integrate our application with the telecomm industry and to target the actual user, the farmers situated at far flung areas.

V. Conclusion and Future Directions

The basic framework of texting for information diffusion, Agr-IS, as presented in this paper will help rural farmers to connect to the urbanized information systems through sophisticated information gathering mechanism. ICTs are employed to disseminate knowledge based information related

to sustainable agriculture like crop nutrition, protection, animal husbandry and biodiversity. The notifications are made to the farmers on demand, along with the precautionary notifications about weather, pest and water management. Such knowledge,

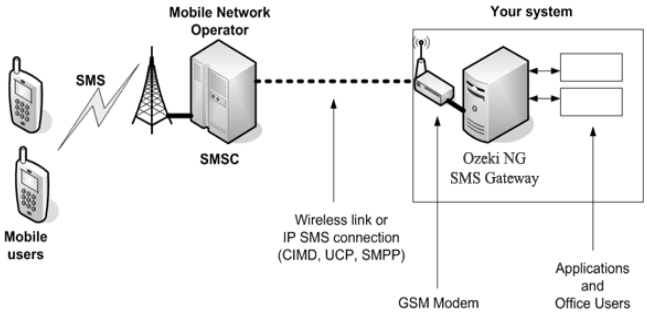

Figure 6. Ozeki NG - SMS Gateway[32]

gained retrospectively, can prove very useful in understanding past problems and in rethinking how agricultural models in information systems might better serve farm management. The seamless integration has been ensured by incorporating the basic framework for Agr-IS with web crawlers for real-time information gathering. The modular structure of the proposed infrastructure will enable it to combine information from various information sources, involved in data logistics, and to function in a very loosely coupled manner.

For future directions, we plan to adopt an e-Government approach to integrate the data extraction service with the information pertaining governmental agencies. This will not only improve the relevance of the responses generated by Agro-DSS for farmer queries but also minimize the gap between the major stakeholders i.e. lower end farmers and the Government.

Not only just the agricultural information dissemination, the above presented architecture is easily extensible to broadcast information regarding human health and veterinaries. people's everyday lives and enable active requests for data

REFERENCES

[1] Imran Sarwar, Zafar Imran, Dr. Muhammad Naeem Ayyaz, "Intra-Operable e-Government for Pakistan: Issues and the Solution" ", 3rd International Conference on E-Governance, pp. 34 - 40, December 2005.

[2] An Introduction to Sustainable Agriculture prepared by Ecological Agriculture Projects Macdonald College of McGill University June, 1989

[3] Corinne Ramey, Katrin Verclas , "Mobile Phones in Mass Organizing: A MobileActive White Paper "

[4] Ramos, A. J. O; The viability of mobile SMS technology for Non-formal Diastance Learning in Asia. A Publication for Melve Development Foundation Inc. Available at www.pandora-asia.org/downloads/05-AAOU_Ramos.pdf

[5] MobileSphere Expands SMS Portfolio with Emergency Broadcast Text Messaging Solution for Educational Institutions, Enterprises and Local Governments. Website: http://www2.mobile-sphere.com/news/sms-broadcast

[6] Feasibility of Collecting Diary Data From Asthma Patients Through Mobile Phones and SMS (Short Message Service) Jacob Anhøj, MD, DIT and Claus Møldrup, PhD, MSc (pharm.) H:S Unit for Patient Safety, Kettegård Alle 30, 2650 Hvidovre, Denmark.

[7] Improving Asthma Control through Telemedicine: A Study of Short-Message Service. Vedran Ostojic, Branimir Cvoriscec, Sanja Barsic Ostojic, Dimitry Reznikoff, Asja Stipic-Markovic, Zdenko Tudjman. Telemedicine and e-Health. February 1, 2005, 11(1): 28-35. doi:10.1089/tmj.2005.11.28.

[8] Hilary Pinnock, Roger Slack, Claudia Pagliari, David Pric and Aziz Sheikh. "Professional and patient attitudes to using mobile phone technology to monitor asthma", 27 March 2006. Primary Care Respiratory Journal. Volume 15, Issue 4, August 2006, Pages 237-245

[9] Mobile phone text messaging can help young people manage asthma. Ron Neville, Alexandra Greene,John McLeod, Andrew Tracy. BMJ. 2002 September 14; 325(7364): 600.

[10] Mobile phone technology in the management of asthma Ryan, D.1; Cobern, W.2; Wheeler, J.3; Price, D.1; Tarassenko, L.2. Journal of Telemedicine and Telecare, Volume 11, Supplement 1, July 2005 , pp. 43-46(4)

[11] Examples from the Field: Texting4Health, Stanford University, Feb 29, 2008 Going Mobile to Improve Public Health

[12] Mary V. Gold, "Sustainable Agriculture: Definition and Term", Special Reference Briefs Series no. SRB 99-02, August 2007.

[13] Geser Hans: Towards a Sociological Theory of the Mobile Phone. In: Sociology in Switzerland: Sociology of the Mobile Phone. Online Publications, Zuerich, March 2004 (Release 3.0). http://socio.ch/mobile/t_geser1.htm

[14] (Bragg et al., 2005 S. Bragg, A. Inman, C. Manning and J. Pitcairn, Assessment of 'Win-Win' Case Studies of Resource Management in Agriculture, Environment Agency, London (2005).

[15] K.B. Matthews, G. Schwarz, K. Buchan, M. Rivington and D. Miller, Wither agricultural DSS The Macaulay Institute, Craigiebuckler, Aberdeen AB15 8QH, UK, Available online 21 December 2007.

[16] J S Anderson, FAA., Feeding the future – sustainable agriculture, published by Australian Academy of Science Posted September 2001.

[17] KellyR.Thorp, KendallC.DeJonge, AmyL.Kaleita, WilliamD.Batchelor, JoelO.Paz, Methodology for the use of DSSAT models for precision, computers and electronics in agriculturexxx (2008) xxxxxx, Article in Press when cited.

[18] Bragg et al., 2005 S. Bragg, A. Inman, C. Manning and J. Pitcairn, Assessment of 'Win-Win' Case Studies of Resource Management in Agriculture, Environment Agency, London (2005).

[19] Groves, J., and J. Da Rin. 1999. Economic and social impacts of farm Internet use. Available at: http://www.rirdc.gov.au:80/reports/HCC/99_35.doc. Accessed Feb. 14, 2000.

[20] S. Newman, T. Lynch and A. A. Plummer. Success and failure of decision support systems: Learning as we go. 2000. 77:1-12. J Anim Sci, Proceedings of the American Society of Animal Science, 1999

[21] Overseas Development Institute (ODI) Website: http://www.odi.org.uk/

[22] Kinghorn, B. P. 1999. Total Resource Management: Tactical optimisation of vertically integrated animal production systems. In: H. A. Abbass and M. Towsey (ed.) Inaugural Australian Workshop on the Application of Artificial Intelligence, Optimisation and Bayesian Methods in Agriculture. pp 17-30. Queensland University of Technology Press, Brisbane, Australia.

[23] Bourdon, R. M., and J. S. Brinks. 1987a. Simulated efficiency of range beef production. I. Growth and milk production. J. Anim. Sci. 65:943-955.

[24] Lynch, T., S. Gregor, and D. Midmore. 2000. Intelligent support systems in agriculture: Can we do better? Aust. J. Exp. Agric. 40:609-620.

[25] Qanita Ahmad, Imran Sarwar, "Texting for General Awareness for Sustainable Agriculture", OIC TELECOM & IT 2008

[26] Pakistan Agricultural Research Council, PARC. Website: http://www.parc.gov.pk/

[27] National Agricultural Research Centre(NARC) Website: http://www.parc.gov.pk/NARC/narc.html

[28] Fitt, G.P., 2000. An Australian approach to IPM in cotton: integrating new technologies to minimise insecticide dependence. Crop Protection 19, pp. 793–800.

[29] M. P. Bange, S. A. Deutscher, D. Larsen, D. Linsley and S. Whiteside, A handheld decision support system to facilitate improved insect pest management in Australian cotton systems Accepted 20 December 2003. Available online 10 March 2004. doi:10.1016/j.compag.2003.12.003

[30] Nam Nguyen, Malcolm Wegener, Iean Russell, Decision support systems in Australian agriculture: state of the art and future development. Corresponding author: Nam Cao Nguyen, Email: n.nguyen@uq.edu.au , Phone: + 61 7 5460 1604. Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

[31] McMaster, G.S., Ascough II, J.C., Dunn, G.H., Weltz, M.A., Shaffer, M.J., Palic, D., Vandenberg, B.C., Bartling, P.N.S., Edmunds, D., Hoag, D.L. and Ahuja, L.R. 2002. Application And Testing Of Gpfarm: A Farm And Ranch Decision Support System For Evaluating Economic And Environmental Sustainability Of Agricultural Enterprises. Acta Hort. (ISHS) 593:171-177. http://www.actahort.org/books/593/593_22.htm

[32] Ozeki NG - SMS Gateway. OZEKI Informatics Ltd. Website: http://www.ozekisms.com/

[33] C.M. Bowman, P.B. Danzig, D.R. Hardy, U. Manber and M.F. Schwartz, The Harvest information discovery and access system, Computer Networks and ISDN Systems 28 (1995) pp. 119-125.

[34] Matthias Eichstaedt, Qi Lu, Shang-Hua Teng Parallel Pro_le Matching for Large Scale Webcasting Lecture Notes in Computer Science Springer-Verlag, pp 17{28, 1998