

ICT Adoption Trends in Agriculture: A summary of the EFITA ICT Adoption Questionnaires (1999 – 2009)

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Abstract

ICT adoption remains considerably short of universal uptake. The EFITA questionnaire data sets, since 1999, attempt to identify trends, reasons and constraints explaining this problem - universally recognized and significant. The main impediments to ICT adoption cited were the lack of 'tailored' ICT applications, their increased sophistication which imposes enhanced human capital requirements, their lack of synchronization with production, market and environment dictates and the essential ongoing End-user and Extension training necessitated. These constraints and other ICT Adoption issues involved were appreciated in the questionnaires as a public concern. Public funding of Information Technology services for farmers was distinctly justified. These and additional insights gleaned from the questionnaires will hopefully alleviate current ICT Adoption constraints, guide relevant ICT policy formulation and development priorities.

Keywords: Information technology, Technological innovation.

Background

Reaping the benefits of Information and Communication Technologies (ICT) in agriculture, remain an ongoing challenge. The range of agricultural and economic benefits is wide and includes better management, better and timely information accessing and dissemination, better and integrated production planning, monitoring and follow up, access to the latest results of research and more. The attempts to define understand and explain the mechanisms and constraints of adopting ICT are not new. Grilliches (1957) studied the Economics of Technological Change using hybrid corn adoption as a case study. Grilliches (1998) identifies a specific ten year lag in a technological change adoption process in agriculture. Gelb and Kislev (1982) quantify farmer (adopter) preferences for technological change via their financing of agricultural research. Gelb and Offer (2005) provide an overall review of ICT Adoption in Agriculture focusing on various perspectives of technological innovation over time.

Rogers (1962) formalizes Technological Change adopter categories - in this case farmers adopting ICT. A quantitative evaluation of Agricultural Software availability and trends since 1990 by Gelb et al. (1997) suggests that by 1997 ICT, as an innovation case study, was no longer an agricultural production novelty.

There were and are very wide variations between uses of ICT in Agriculture, competence in their use, the benefits derived and their distribution. They are instrumental in partially explaining the differences in ICT Adoption rates. Although no longer a novelty ICT Adoption for Agriculture and Rural Development today remains a continuously studied critical issue, at regional, national and international levels. An early example of ongoing EU interest in ICT Adoption for agriculture was manifested in an EU sponsored workshop which analyzed in detail the use of Internet for Extension Gelb, Bonati (1997).

See the current EU FP7 ICT key objectives for a current example of EU interest: http://ec.europa.eu/information_society/activities/ict_psp/about/index_en.htm.

The USDA 'Computer Ownership and Use Surveys' NASS (2007) evaluates the ICT adoption rates since 1997. The surveys provide a comparative quantitative baseline which includes a very large sample of US farmers. Their summary illustrates a specific ICT adoption time lag – in this case between computer access and Internet access. It roughly indicates e.g. a 10 year Internet access time lag similar to that described by Griliches (1988) for Hybrid corn.

These results obviously mask a wide range of constraints, impediments and reasons for different rates of ICT Adoption, alternatives and results. By 1999 generalized evaluations of ICT Adoption for Agriculture had been initiated via a series of EFITA conferences. The evaluation included policies, Extension services and their results, information dissemination alternatives, computerized decision support systems and other ICT. As part of this effort EFITA sponsored with the Samuel Neaman Institute for Advanced Studies in Science and Technology a series of questionnaires which tried to identify ICT Adoption constraints. The first data set was collated from the Second EFITA Conference held in Bonn in 1999, Gelb, et al. (2004). By the time of the 5th EFITA conference (hosted in 2005 in Villa Real, Portugal) conference deliberations were understandably focused on the dilemma: *Is ICT Adoption for Agriculture Still an Important Issue?* The conference included dedicated sessions and a summary plenary discussion.

The overwhelming response from the Villa Real conference participants asserted that ICT Adoption for Agriculture and Rural Development remains a major professional, national and international concern. This despite the ICT Adoption experience accumulated in Agriculture and the ICT proficiency gained since at least the early 1960s. As a generalized ICT Adoption observation it was suggested that if cost is eliminated as a constraint the other ICT adoption impediments, in both developed and developing countries, share essential commonalities. Training as one example was identified as a common, dominant alleviating ICT adoption factor. This specific training was considered to be a public responsibility with justified public funding to promote ICT Adoption and services, however with qualifications. The latest EFITA questionnaire replies were collated from the recent 6th EFITA Conference held in 2007 in Glasgow, Scotland. They reiterated the consensus that ICT Adoption for Agriculture '*remains a major professional, national and international concern*'.

This paper attempts to review, identify and highlight the constraints to ICT Adoption for Agriculture as reflected in the replies to the five 'Bonn to Glasgow' EFITA questionnaire data sets. Hopefully the insights gained will contribute to alleviating current ICT Adoption efforts and guide the formulation of ICT policies, ICT development priorities and ICT applications.

Questionnaire Methodology

Since the 1999 EFITA conference in Bonn each EFITA Conference participant was requested to fill out the standard questionnaire as follows:

- a. Do you think that there are problems with the uptake of ICT in agriculture? (Yes/no)*
- b. Do you think there are unique uptake problems with any of the following: Decision Support Systems (DSS), Management Information Systems (MIS), Internet, Precision Farming, Process Control, Production Models, E-commerce, others. (Yes/no for each)*
 - 1. What are the factors limiting the use of ICT by farmers?*
 - 2. What are the factors limiting the use of ICT by Extension working with farmers?*
 - 3. What are the factors limiting the use of ICT by research working with farmers?*
 - 4. What are the consequences for farmers not using ICT: Today and in the near Future:*
 - 5. What are the consequences for Extension not using ICT: Today and in the near Future:*
 - 6. Should public funds help to finance Information Technology Services for Farmers?*

The two questions - a and b - were added from the 2001 questionnaire onward.

The resulting five Conferences questionnaire data sets focus on results from mostly European countries – 25 overall with 8 of them represented in all conferences. The core Conference participants were a relatively homogeneous group. Most conference participants had been collaborating over the years via their academic, extension and organizational responsibilities and interactions. The consistency of their replies supports the validity of the trend overview in these questionnaire data sets.

Some important drawbacks of this EFITA questionnaire procedure must be noted. As a convenience sample the replies are not statistically robust. The conference participants were a random sample from similar, related but not identical scientific disciplines, they did not share the same level of experience/competence, the participants had different levels of interaction with farmers and not all countries were equally represented in the data sets. The replies reflect personal and thereby biased opinions – which in some cases might have been more accurate if expressed by a different set of participants for example farmers answering question 1. With this said and factored as trend evaluation the replies/data sets do suggest comparative insights, reasonably expressed in the summaries from each conference.

The reply categories in each question were generalized from a longer list of replies. The long and detailed list was a direct result from the option of unrestricted opinions open to interpretation by the respondents. For example 'Cost' reflects all the various replies related to ICT expenses, etc.

The following list details the number of replies from each of the five EFITA Conferences reviewed (with n= received replies): Bonn (1999) n = 58; Montpellier (2001) n = 65; Debrecen (2003) n = 52; Villa Real (2005) n = 60; Glasgow (2007) n = 56.

Summary of Results

Table 1. *Do you think there are problems with the uptake of ICT in Agriculture?*
(% answering yes to Question a)

	Montpellier 2001	Debrecen 2003	Villa Real 2005	Glasgow 2007
Yes	53.2	78.8	96.6	94.4

In 2001 'about half' (53.2%) of the respondents to question a. replied that there is a problem with the uptake of ICT in Agriculture. In 2007 'practically all' (94.4%) of the respondents asserted that there is such a problem. It is important to note that such broad generalizations and interpretation are the rule in reading the results of the questionnaire replies. Conclusions such as 'Yes there is a Problem' are valid when the differences are of such a clear magnitude.

A minority of participants in the Conferences summary discussions expressed the opinion 'that since everyone today has access to a computer, for so many years' then 'No - there is no problem with ICT uptake'. The questionnaire replies leave little doubt about the validity of the majority consensus that identified a problem. This consensus raises two fundamental concerns:

1) if there is such an ICT uptake problem in agriculture for such a long period, and assuming it is a question of economic significance, then why has it not been solved by now, how is this uptake shortcoming to be overcome and under whose responsibility – if any? Specifically is this an inevitable consequence of the relentless pace of technological innovation and ever growing volume of available information; Is this a case of 'playing tag' - with the public training services lagging behind the latest ICT – by the time they are mastered they are already outdated.

2) what is the contribution of ICT Adoption to rural viability as derived from the success of the agricultural sector? This with 'Agriculture' is no longer confined to 'farming'.

The results of Question b. in Table 2 takes Question a. a step further by an attempt to identify which are the problematic technologies within the time framework of the EFITA questionnaires.

Table 2. *Do you think there are unique uptake problems with any of the following ICT:*
(% answering yes to Question b)

	Montpellier 2001	Debrecen 2003	Villa Real 2005	Glasgow 2007
Decision Support Systems (DSS)	50.7	38.5	53.3	62.5
Management Information Systems (MIS)	32.3	26.9	38.3	35.7
Internet	33.8	26.9	36.7	41.1
Precision Farming	47.6	32.7	43.3	53.6
Process Control	24.6	21.2	27.1	25
Production Models	49.2	36.5	38.3	44.6
E-commerce	46.1	36.5	45.0	41.1

The uptake of DSS as a major tool in agricultural production in 2001 was considered by half (50.1%) of the respondents to be a problem. It was not alleviated by 2007 as observed by two thirds of the respondents (67.1%). In fact uptake declined. (This may be the result of e.g. more complicated and sophisticated DSS which require more than ICT proficiency).

To a lesser degree these replies represent the MIS results as well. Conventional wisdom suggests that Internet is by now so universally prevalent and potentially beneficial to farmers that it is at least 'widespread'. It is important to observe that the Questionnaire Internet results are different and consistent with the 'ten year adoption lag' suggested by Rogers and the NASS survey with 41% identifying an adoption problem. This difference in opinion and replies is maintained for Precision Farming and Production models which for 2007 indicate a decline in uptake. The E-commerce uptake replies are consistently low – perhaps representing another example of a time lag in adoption. Another possible explanation is the existence of alternatives for accessing timely market information and conduct of transactions. Increased prevalence of mobile communications comes to mind and possible changes in the structure of markets – e.g. farmer marketing cooperatives and direct advance farmer-wholesale contracting.

All in all there are no dramatic and obviously successful uptake results in adoption of any of these ICT categories over time. If the questionnaires indicate a generally accurate description of ICT Adoption in Agriculture then they support two main concerns: who will be the agents of change to alleviate this situation and should this issue be a public sector concern? One encompassing alternative for example could be to leave ICT Adoption issues for the 'invisible hand of the market'.

These questions are further focused by an attempt to rank the specific constraints for farmers' uptake of ICT for their farming – as seen by the respondents. At this point it is imperative to note that in 2007 there are many instances where farmers, their agricultural activities and their marketing food chains are thoroughly 'ICT Imbued'. For them the two dominant questions: 'Is ICT Adoption a constraint' and 'Can ICT Adoption be economically beneficial' are irrelevant. To be clear –it is justified to expect that a rational farmer will adopt a proven ICT and attain the economic benefit from that specific available and affordable farming technology (e.g. ICT). Since the questionnaire results indicate otherwise it is reasonable to expect that the constraints and reasons would be identifiable and possibly explained - from the farmer's point of view. The replies to Question 1 attempt to do so via the relative changes of ICT Adoption constraints over the past ten years – Table 3.

Table 3. *What are the factors limiting the use of ICT by farmers (%) (Question 1)*

	Bonn 1999	Mont. 2001	Debrecen 2003	Villa Real 2005	Glasgow 2007
Inability of farmers to use ICT	29.3	3.0	34.6	45.0	12.5
unperceived economic or other benefits	27.6	27.6	21.2	23.3	21.4
Lack of technological infrastructure	18.9	6.0	23.1	35.0	28.6
Cost of technology	17.6	32.3	25.0	25.0	23.2
Not enough time to spend on technology	12.1	16.9	19.2	10.2	23.2
Do not understand the value of ICT	8.6	16.9	26.9	30.0	17.9
Lack of training	8.6	20.0	19.2	16.7	17.9

In 2005 almost half of the respondents (45%) suggested that farmer ICT incompetence was a dominant reason for not adopting ICT for farming. About a third of the respondents added that the value of ICT was not understood (30%) and/or to a lesser extent (23%) replied that the economic benefit was unperceived. A third of the respondents (35%) added technological infrastructure limitations (e.g. poor rural communication facilities) as a constraint. Cost and training although important were not identified as major constraints. Comparing 2007 replies indicates a major improvement in farmer ICT proficiency (12.5%), an understanding of the value of ICT (17.9%) and an expected improvement in infrastructure. The argument that ICT saves time is refuted in 2007 by all respondents to the extent that 'imposed time requirements' are identified as a considerable constraint (23%).

A point of interest is the difference in the replies to 'unperceived economic or other benefits' (21.4%) and 'Do not understand the value of ICT' (17.9%). The explanation apparently stems from the agreement that general perception of value is high (82%) as is the ability to utilize ICT (87% since 12.5% replied otherwise). This 'unperceived economic benefit' result suggests a gap between what is available and what is needed. This interpretation based on the replies from 2003 – 2007 supports the conclusion that there has been major ICT proficiency progress and understanding between these years.

The most important conclusion that can be gleaned from the replies to Question 1 is that the inability of farmers to use ICT has essentially been overcome – at least by the innovators, the early adopters and the early majority (see Roger's terminology). Still all in all the general trend of the above identified constraints suggests that over a ten year period the identified constraints have still not been satisfactorily overcome. Assuming that the questionnaire replies adequately reflect reality the question remains why?

Table 4 helps in explaining the farmer ICT Adoption constraints identified in Table 3 by looking at the perceived consequences for farmers currently not using ICT albeit over a shorter period of time. The clear farmer recognition that there is a loss of competitiveness with a specific mention of efficiency and contact with timely information by not using

ICT probably explains the fact that farmers attained much better ICT proficiency see Question I – again with a time lag since 2001.

Table 4. *What are the consequences for farmers not using ICT? (%) (Question 4)*

	Bonn 1999	Mont. 2001	Debrecen 2003	Villa Real 2005	Glasgow 2007
Loss of competitiveness	32.7	52.3	28.8	30	30.4
Loss of production and management efficiency			11.5	25	27.3
Loss of contact with information, innovations	27.6	18.5	26.9	23.3	25
Loss of contact with timely information			1.9	15	23.2
Problems in the future			26.9	23.3	12.7

A constant third of the replies identify '*Loss of competitiveness*' as an obvious consequence. The same to a lesser degree can be observed for '*Loss of contact with information, innovations*'. This point however comes into a sharp focus over time since 2003 with the qualification of '*Loss of contact with timely information*'. The receding result over time for '*Problems in the future*' suggests that farmers have an understanding of ICT benefits (*since 2005 see 'ICT contribution to production efficiency'*) and have confidence in their ability to extract them from the ICT available to them. Looking at the lower than expected result for the uptake of Internet (above) supports this observation in a roundabout way by suggesting that farmers are aware of, and use alternatives. This result is supported by the growing prevalence of mobile phone service options such as SMSs (Short Message Service) for immediate dissemination of plant protection warnings, weather forecasts, market opportunities, available prices and more (see EFITA newsletters for current links and updates at <http://www.efita.net/>). An unavoidable impression from the relatively low results suggests that the replies factor in the large segment of farmers who are ICT proficient - perhaps the innovators and early majority of adopters.

Table 5 relates to Extension's role as a training entity and information provider in the context of the perception of Extension working directly with farmers.

Table 5. *What are the factors limiting the use of ICT by Extension working with farmers? (%) (Question 2)*

	Bonn 1999	Mont. 2001	Debrecen 2003	Villa Real 2005	Glasgow 2007
Cost and/or lack of funds or equipment	18.9	4.6	25.0	16.7	7.1
no ICT access and/or infrastructure	8.6	7.7	23.1	18.3	16.1
Lack of training	13.8	21.5	7.7	10	5.4
Lack of ICT experience and skills	24.1	-	17.3	20	5.4
Unsuitable, incompatible, programs and/or information	18.9	20.0	21.2	20	23.2

The results by 2007 show that Extension's 'Lack of training'(5.4%), 'Lack of ICT experience and skills'(5.4%) and 'Cost of equipment'(7.1%) cease to be significant constraints. This could be the result of the fact that Extension is funded mainly by public sources. Furthermore the conclusive replies of Question 6 below suggest recognition of inadequate public funding for Information Technology Services for farmers – which includes Extension services. This interpretation is supported by the decreasing rate of replies suggesting qualifications for this support of public funding. Question 5 tries to evaluate the consequences of this situation.

Table 6. *What are the consequences for Extension not using ICT? (%) (Question 5)*

	Bonn 1999	Mont. 2001	Debrecen 2003	Villa Real 2005	Glasgow 2007
Loss of relevance, confidence and/or credibility	53.4	27.7	25	30	7.1
Isolates extension as a source of information, innovation and research results	22.4	24.6	17.3	15	8.9
Inefficient and inferior service			32.7	26.7	28.6
Will become obsolete	6.9	2.0	28.8	23.3	10.7

The replies imply ICTs considerable impact on Extension's relevance to farmers, efficiency of the service rendered and a necessary condition for continued service viability. In 2007 the replies indicant a significant change - the relevance of ICT for Extension elicited only 7.1% of the replies. This reduction perhaps indicates the perception and importance of alternatives to Extension – as suggested above. Regardless almost a third of the respondents (28.8%) identify the importance of ICT to the quality of Extension's service. This includes indirect use of the various technologies involved and the content Extension provides. For example as mentioned above the ever increasing use of SMS as a source of information does not necessarily indicate Extension as the source of the information disseminated. ICT would consequently not be cited here in the 'ICT Adoption rate' replies. A case in mind would be the Extension's plant protection guidelines originally formulated by research and or Extension and later disseminated by various entities. These could be regional farmer's associations, companies providing chemicals and spraying services, marketing agencies, consumer/environmental preservation groups, etc – using faxes, SMS, weekly farmer meetings and/or preseason training, leaflets, daily bulletins and more.

The results of Question 6 should be read as follows – since 1999 a majority of the replies (79.3% to 81.8%) indicate the need of public financing to support Information Services for farmers. In the earlier replies two thirds (Bonn 67% and Montpellier 67.8%) qualified their approval – a qualification which has changed in Glasgow and been reduced to less than one third - 28.6% of the replies. Regardless all in all the current 80% support level for public funding since the 2003 consensus is maintained.

Table 7. *Should public funds help to finance Information Technology Services for farmers? (%) (Question 6)*

	Bonn 1999	Mont. 2001	Debrecen 2003	Villa Real 2005	Glasgow 2007
yes	12.1	3.1	53.8	61.0	53.6
yes with qualifications	67.2	64.7	25.0	27.1	28.6
'Yes' Sub total	79.3	67.8	78.8	88.1	82.2
no	20.7	21.5	17.3	8.5	10.7
no with qualifications			1.9	0.0	5.4
other		10.7	1.9	3.4	1.8

Discussion

The EFITA Questionnaire data sets concur that ICT Adoption for Agriculture remains a cardinal problem and that the issues are of public concern to a degree that justifies public funding. They enable a generalized portrayal of the trends of ICT Adoption constraints over the past ten years and the information services provided by Extension. These included initially introducing farmers to ICT – a function basically completed during the 1990s. All these suggest guidelines for Extension priorities and farmer initiatives to overcome ICT Adoption constraints. The questionnaires identify the details of the Extension information dissemination services in the context of ICT uptake by the farmers and the consequences for not deriving ICT Adoption benefits. It is imperative to note that the results and insights are significant and should not be masked by the many examples of outstanding successes in ICT development and adoption. They alone cannot alleviate the widespread ICT Adoption for Agriculture problems and shortcomings of at least the 'late majority'

The results for uptake of specific ICT reflect both the complexity of agricultural production and the relative uniqueness of specifically identified ICT. The years reviewed by the questionnaires are characteristically a transitional period of technological change with dynamic developments, upgrading and adjustments made by ICT providers, ICT service providers and the ICT users themselves. One dominant characteristic of such a transitional period is an identified 'Top Down' reality. In this case ICT producers provide their standard wares – with applications not necessarily tailored to farmer and/or Extension specifics - as indicated in table 5.

The replies in Table 2 re specific uptake difficulties suggest that EFITA respondents identify Farmer ICT Adopters in agriculture today as Roger's (1962) 50% 'Late Majority'. In many countries this quantification has critical practical and political implications. Maintaining the viability of rural/agricultural communities is a vital national interest considering the current declining farm-gate profitability of small scale farmers, delayed adoption of technological change, ageing farm populations and accelerating migration to urban environments. The Questionnaire replies in Table 7 confirm this urgency by asserting that ICT Adoption to provide ICT services to farmers enabling rural viability is a public concern unquestionably worthy of public investment.

These observations may bear heavily on the development and adoption of cutting edge ICT for agriculture. A public policy for the developing Semantic Web (SW) methodology now in the takeoff stage and its application for agriculture demonstrates all the above issues. The questionnaire replies suggest justification of public funding of SW, Extension efforts to attain SW proficiency, ever friendly ICT to facilitate SW services and sharing development costs with participating farmers by indicating their SW priorities. Agriculture stands to gain significant benefits derived from increased efficiency due to ICT enabling management of information as recognized in Table 4. This in turn will enhance rural viability e.g. by providing alternatives for unemployed labor previously employed in less efficient agricultural production tradition. The inevitable conclusion from the trends identified in the EFITA questionnaire data sets is the need for a deeper understanding of ICT Adoption for agriculture. The insights can provide at least an indicative guide for ICT development priorities and rural development policies.

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