

## AGRICULTURAL INFORMATION AND DECISION SUPPORT BY SMS

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**Abstract.** A warning system where up-to-date and local agricultural information is communicated by SMS is described. The system has two types of warnings: Push-type warnings are sent regularly or when certain criteria are met, as specified by the user, while pull-type warnings are sent on the user's request by SMS. A web-based DSS, which require data updated frequently by the user, has been enabled for operation by SMS. Applying widely distributed and well-known technology, the SMS systems make information and decision support available to the farmer whenever he needs it and wherever he is. The paper describes the SMS systems and analyses the uptake by users.

### 1. Introduction

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. PlanteInfo (Jensen et al., 2000), [www.planteinfo.dk](http://www.planteinfo.dk), is a Danish web site hosting a broad range of dynamic information and decision support systems for plant production. Many farmers, however, are reluctant to use computers and often they need the information when they are in the field – far away from a computer. Modern mobile handsets can solve this problem, since they enable web access, exchange of data and execution of Java programs by wireless connection (Hansen, 2003). It is assumed, that only a minority of Danish farmers own such a handset currently. Most Danish farmers, however, own an ordinary mobile telephone, which can send and receive SMS (Short Message Service).

A warning system, called eWarning, where agricultural information is sent as a plain SMS has been implemented in PlanteInfo. Furthermore, a decision support system for irrigation has been enabled for operation by SMS. There are two types of warnings in the eWarning system: Push-type and pull-type. Push-type warnings are sent regularly, as specified by the user, while pull-type warnings are sent only on request by the user. The following three sections describe push-type and pull-type warnings and operation of a DSS for irrigation management, respectively. Section 5 analyses the uptake of the system by users.

### 2. Push-type eWarnings

Push-type eWarnings are received regularly and automatically. This requires that the user sets up a warning service from a web page in PlanteInfo. The user selects one or more eWarnings and specifies how often or under what circumstances each eWarning must be sent. SMSs are sent according to the specification of the eWarnings, until either the user cancels the service, or it is no longer relevant. The following push-type eWarnings were available in 2002:

- Hourly, local weather forecast for the next hours for temperature, precipitation, relative humidity, wind speed and wind direction
- Daily weather observations for the past 5 days and forecasts for the next 4 days for precipitation and relative humidity
- Daily risk indices of potato late blight calculated from weather observations and forecasts
- Field recordings of important diseases and pests in winter wheat

The various types of eWarnings differ in several ways, e.g. the data source, the frequency of updating and the triggering mechanism. Therefore, the specification of eWarnings differs, as illustrated by the following two examples.

**A. Specification of push-type eWarning for hourly, local weather forecast.**

My set-up of 'eWarning - 48 hours forecast, 8 o'clock'

Subject:  
Local, hourly forecast for the next 48 hours, calculated at 8 o'clock

Select parameters for the eWarning:  
 Precipitation  Temperature  Relative humidity  Wind speed  Wind direction

Select if you want the eWarning as SMS or e-mail:  
 SMS to mobile number 12345678   
 E-mail to xyz@agrsci.dk

Select the frequency of the eWarning:  
 Every  day(s)  
 Next time:

**B. The corresponding SMS.**

```
Forecast 14/02:08
Grid 0898
Hr Rain Temp
09 0.0 4.6
10 0.0 4.9
11 0.0 5.2
12 0.2 6.0
13 0.5 6.4
14 0.1 6.1
15 0.0 5.7
www.planteinfo.dk
```

**Figure 1. A: Specification of push-type eWarning for hourly, local weather forecast. B: The corresponding SMS.**

*Fig. 1.A* shows the web page where users can specify an eWarning service with an hourly weather forecast. The user selects which of the weather parameters to receive, the frequency of SMS reception and the starting date. Note that it is possible to receive eWarnings as e-mail also. The mobile telephone number and the e-mail address of the user are known by the system through the subscription system of PlanteInfo. Likewise, the geographical location of the user is known, and this is used to ensure that the user will receive local weather forecasts. *Fig. 1.B* shows an SMS corresponding to the specified eWarning. The SMS contains local forecasts for the selected weather parameters for as many hours, which can be contained in the limited size of an SMS. When the eWarning is sent as an e-mail, the forecast covers the next 48 hours.

The source of weather data in PlanteInfo is AMIS (AgriMeteorological Information System) (Hilden and Hansen, 1999) under Danish Meteorological Institute (DMI), where observations and forecasts are interpolated to 10×10 km squares. The AMIS weather data are updated by DMI several times per day, depending on parameter. The issuing of SMSs corresponding to weather-based eWarnings is triggered by the updating routines of the weather database.

Select recordings. You can give thresholds triggering the issue of the eWarning:

| Select                              | Recording   | Variety | Issue at threshold              | Current level (Recorded week 20)     |
|-------------------------------------|-------------|---------|---------------------------------|--------------------------------------|
| <input checked="" type="checkbox"/> | Yellow rust | Ritmo   | <input type="text" value="10"/> | 0 % fields with attack               |
| <input checked="" type="checkbox"/> |             | Kris    | <input type="text" value="5"/>  | 0 % fields with attack               |
| <input checked="" type="checkbox"/> |             | Bill    | <input type="text" value="1"/>  | 0 % fields with attack               |
| <input checked="" type="checkbox"/> | Mildew      | Ritmo   | <input type="text" value="10"/> | 9.5 % fields with treatment need     |
| <input checked="" type="checkbox"/> |             | Kris    | <input type="text" value="5"/>  | 0 % fields with treatment need       |
| <input checked="" type="checkbox"/> |             | Bill    | <input type="text" value="1"/>  | 0 % fields with treatment need       |
| <input checked="" type="checkbox"/> | Aphids      |         | <input type="text" value="10"/> | No info % fields with treatment need |

Select if you want the eWarning as SMS or e-mail:

SMS to mobile number 12345678

E-mail to xyz@agrsci.dk

Select when you want the eWarning:

Every Tuesday after new recordings, regardless of the levels

Whenever the recordings exceed one or more of the entered thresholds

Record. w. wheat week 21

Yellow rust

Ritmo 1.4

Kris 6.8\*

Bill 0

Mildew

Ritmo 25.3\*

Kris 2.7

Bill 1.3

Aphids

No info

\*) Above your threshold

PlanteInfo

A.
B.

**Figure 2. A: Specification of push-type eWarning for field recordings of diseases and pests in winter wheat. B: The corresponding SMS.**

*Fig. 2.A* shows the web page where users can specify an eWarning with the latest field recordings of diseases and pests in winter wheat. The user selects which diseases and pests to receive recordings for, similar to the selection of weather parameters of the eWarning for hourly weather forecasts. In addition, the user can specify thresholds for the recordings, such that an SMS will only be sent when the recordings exceeds one or more of the thresholds. The corresponding SMS is shown in *Fig. 2.B*. The information in the SMS is not local. Rather, it is the percentage of recorded fields with either attack or treatment need.

The source of data for this eWarning is designated Danish agricultural advisers who perform weekly field recordings in trial fields all over the country. The data are collected, validated, stored and published by the Danish Agricultural Advisory Centre (DAAC). An employee at DAAC responsible for the recording data triggers the issuing of SMSs for this eWarning. This is done with a protected web page where the employee first activates a program at the PlanteInfo server, which causes the relevant recordings to be extracted from the database of DAAC and transferred to PlanteInfo in XML format. The employee verifies the transferred data before accepting their publication. Finally, he clicks a button on the web page, which starts the issuing of SMSs with the new recordings.

### 3. Pull-type eWarnings

A pull-type eWarning is sent only when a user requests it by sending an SMS message to a particular telephone number. This causes a program to be called, which can detect which type of information is requested from the SMS message. The program finds the user and his geographical location in the subscription database from the telephone number, extracts the relevant data, generates the requested SMS message and returns it to the user in a matter of few minutes.

The only pull-type eWarning available in 2002 was the hourly weather forecast. The content of this eWarning is identical to its push-type variants (*Fig. 1.B*). It is specified by the letters of the requesting SMS message. If the message contains 'T', 'N', 'F', 'V' or 'R', the

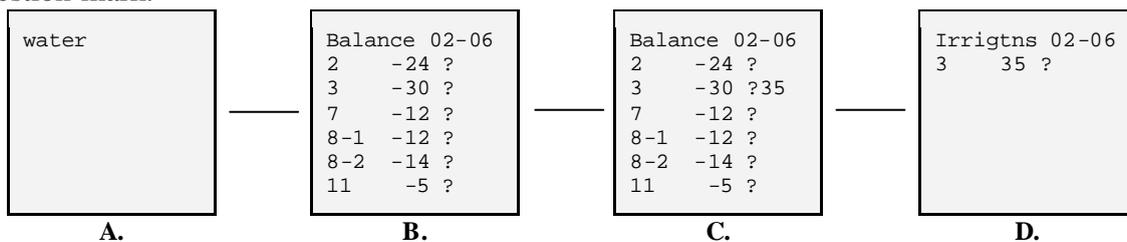
local, hourly weather forecast is sent with the parameters corresponding to the letters: Temperature, precipitation, relative humidity, wind speed and wind direction, respectively. Hence, the message 'TF' yields an SMS with forecasts of temperature and relative humidity. If the message contains none of the valid letters an instruction is sent.

#### 4. Irrigation Manager

PlanteInfo hosts a decision support system for irrigation, Irrigation Manager, which can provide farmers with information on irrigation requirements for their individual fields (Jensen and Thysen, 2002). The Irrigation Manager requires set-up with information per field on soil type, crop and emergence date for spring crops. Local weather data (observations and forecasts of daily temperature, precipitation and potential evaporation) are provided by PlanteInfo's weather database. The weather data are used in the model of Irrigation Manager (Plauborg and Olesen, 1991; Olesen and Plauborg, 1995) to simulate the development and growth of the crop and the dynamics of the soil water. The essential output is irrigation requirements for each field.

The user can adjust the simulations by supplying own observations and hence improve the quality of the decision support. Notably, it is recommended that users supply daily measurements of precipitation, since interpolation of this weather parameter to the location of the user is often imprecise. It is obviously imperative for good decision support that the user supplies data about all applied irrigations. This communication of data is normally done via web pages with HTML input forms.

A service has been implemented in PlanteInfo, which enables the communication with Irrigation Manager to be done also via SMS. The user can enter data for measured precipitation as well as applied irrigations. *Fig. 3* illustrates the communication when the user enters applied irrigations to the database. Similar to pull-type eWarnings, the user first sends an SMS with a precisely structured text message, in this case 'water' (*Fig. 3.A*). The program receiving the SMS recognizes the keyword and returns an SMS with the irrigation requirement of each of the user's fields (*Fig. 3.B*). The user is identified by the telephone number. Each field has a line in the SMS with a field number, the irrigation requirement and a question mark.



**Figure 3. Communication to update irrigations in Irrigation Manager via SMS.**

**A: User requests irrigation need of fields. B: User receives SMS with irrigation needs. C: User enters applied irrigation for field 3. D: User receives SMS with updated irrigation data.**

The user can now use the reply or forward function of the mobile telephone to open the received SMS and write the data for applied irrigations directly into this SMS after the question mark (*Fig. 3.C*). The reason for this procedure is to ensure consistency in the field identifications. In this way, the input forms of the web pages are emulated by SMS. The user sends the SMS and receives a confirmation that the database has been updated with the entered irrigation data (*Fig. 3.D*).

Similarly, by sending an SMS with the message 'rain' the user receives the local precipitation for the past seven days. The data can be edited and returned in an SMS, ensuring the format of the dates corresponding to the precipitation data are consistent with the database of Irrigation Manager.

## 5. User uptake of the eWarning system

The SMSs sent out in the period from 1<sup>st</sup> April to 28<sup>th</sup> September were analysed. During these 181 days 64,878 SMSs were sent to 397 different users. This corresponds to 343 push-type and 16 pull-type SMSs sent out per day on average. The number of users is not very high, but many users are quite dedicated. The number of SMSs received per user ranges from 1 to 869 with an overall average of 163. The 397 users comprise 15 per cent of the users of PlanteInfo with access to the SMS systems in the period (approximately 2600).

Table 1 shows how the SMSs are distributed on the various eWarnings. Clearly, the push-type eWarnings with hourly and daily weather data are by far the most popular, counting for 54 and 39 per cent of all SMSs sent, respectively. It should be noted that it has been possible to receive an hourly forecast four times per day during the entire period, while the recordings in winter wheat has only been updated weekly for eight weeks. Likewise, it has only been possible to select the risk of potato late blight and irrigation management during parts of the period when these topics has been agronomically relevant.

**Table 1. Distribution of SMSs and users of eWarnings during 181 days in 2002.**  
The Irrigation Manager system is categorized as a pull-type eWarning here.

| eWarning type | eWarning                   | Number of SMSs | Number of users |
|---------------|----------------------------|----------------|-----------------|
| Push          | Hourly weather forecast    | 34,768         | 234             |
|               | Daily weather data         | 25,391         | 204             |
|               | Risk of potato late blight | 1,552          | 22              |
|               | Recordings in winter wheat | 320            | 46              |
|               | <b>Total push-type</b>     | <b>62,031</b>  | <b>320</b>      |
| Pull          | Hourly weather forecast    | 2,358          | 121             |
|               | Irrigation DSS             | 475            | 28              |
|               | <b>Total pull-type</b>     | <b>2,847</b>   | <b>139</b>      |
| <b>Total</b>  |                            | <b>64,878</b>  | <b>397</b>      |

It is a bit surprising that only 6 per cent of the SMSs with hourly weather forecasts are pull-type. One reason could be, that this is a type of information which users want daily, rather than occasionally. Therefore, it is more convenient to receive it automatically.

57 per cent of the SMSs for the Irrigation DSS were sent to submit local measurements of precipitation. The remaining were sent to see the irrigation need or to submit data for irrigations.

## 6. Discussion

This paper has described operational examples where simple SMSs are used as a medium for communication between suppliers and users of information and decision support. The SMS can be used for various types of communication, according to their intended effect on the receiver. These types include the following:

- **Information.** The SMS contains all the relevant information about the topic. The user needs not do further.
- **Notice.** The SMS notifies that some information is available. It cannot contain all the relevant information, but may contain a reference (e.g. url) to further information. The user decides whether or not it is necessary to act.
- **Alarm.** The SMS notifies by its arrival alone that some event has occurred to which the receiver must take action.
- **Dialog.** A sequence of related SMSs consisting of requests and responds between user and supplier.

The examples in the eWarning and Irrigation Manager systems cover these types of information: The eWarnings with weather data are self-contained pieces of information. The eWarnings about the risk of potato late blight and recordings of diseases and pests in winter wheat are 'notices', which the farmer can use to decide if it is necessary to act; e.g. go to the field, to search more information, or to consult a DSS. The eWarning with recordings in winter wheat can also be considered an 'alarm', when the user has specified thresholds to trigger the issuing of the SMS. Finally, the operation of the Irrigation Manager DSS by SMS consists of a 'dialog'.

The systems with SMS communication have been developed to evaluate the market for this medium. The experience from the first year has been satisfactory. A relatively small number of users have adopted the system and become frequent users. We believe that the system can be successful within short time, since it uses technology already available and known to most potential users.

In the longer run, the SMS technology is too primitive with only unstructured text. With the dialog communication to operate the Irrigation Manager DSS we had to stretch the solution beyond the limits of an SMS in order to emulate an input form. This resulted in an operational, though not very user-friendly solution. MMS and Wap technologies are available already, allowing images, animations, sound, hypertext etc. The technological development within mobile telephony and wireless Internet access will undoubtedly enable more elegant solutions in the near future. If farmers are willing to adopt the new technologies, such solutions may become successful.

The development of the eWarning system will continue with more types of information. We find a number of weather-based, threshold-triggered, push-type eWarnings particularly interesting. For example, with an eWarning for spraying weather the user receives an 'alarm' SMS when the weather forecast promises good conditions for spraying of pesticides, i.e. mainly low wind and no precipitation for a number of hours. The user can specify the conditions triggering the issuing of the SMS. Similarly, we envision eWarnings for harvest weather and frost risk. Obviously, such weather-based eWarnings also have a market outside agriculture, since we all make plans under the uncertainty of weather. eWarnings forecasting, say sailing weather, barbeque weather or driving conditions, as specified by the user, could become popular.

**LITERATURE**

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