# ESTIMATING VOLUME OF WATER USAGE FOR IRRIGATION IN MALTA 2009

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**FOREWORD**

Artificial irrigation is an important aspect of Maltese agriculture. To date, NSO has not carried out any empirical studies to estimate the volume of water used for irrigation. Consequently, statistics on the sources and types of irrigation have been collected through various surveys.

Due to the lack of monitoring equipment, the Agricultural and Fisheries Statistics unit (hereafter referred to as the Unit) had to find out different means of estimating water usage. During the initial stages of the survey, meetings with selected agricultural retail outlets were held to obtain more information on irrigation methods in Malta. Furthermore, the questionnaire was tested beforehand to find out if the respondents could actually fill in the data required.

A panel survey including 799 agricultural holdings was undertaken over 52 weeks to determine the volume of water used for irrigation in Malta. Where possible, all the farmers who were selected for the survey were taken from the Integrated Administration and Control System (IACS) register to ease the burden both on farmer and interviewer. It is common practice that very few farmers monitor their usage of water for irrigation and thus our data collection focused on the volume of water used per crop on each individual land parcel. The parcels pertaining to each agricultural holding were monitored over a period of four weeks in which the volume of water used for irrigation was calculated. Following these calculations, an estimation of the overall volume of water used for irrigation on all agricultural holdings could be carried out.

As a result of the survey, the volume of water used for irrigation in agriculture for the agricultural year 2008/2009[1] amounted to 19.1 million cubic metres. The total irrigated area amounted to 2,891 hectares, or 29 per cent of the total utilised agricultural area.

I would like to thank Mary Rose Debono, Ronald Tanti, as well as the other staff members of the Agricultural and Fisheries Statistics unit for their work and enthusiasm throughout this complex project. My appreciation also goes to Joseph Bonello for his support and guidance.

Michael Pace Ross
Director General

March 2010

[1] September to August

# 1 INTRODUCTION

## 1.1 BACKGROUND

Currently, the only estimates available of irrigation by crop have been compiled by the Malta Resources Authority. These estimates were calculated based on the type of crop grown and the requirement of water needed. As a result, an empirical study was required to corroborate the current estimates of the volume of water actually used for irrigation purposes.

The major problem facing data collectors is that a substantial volume of water used for irrigation is extracted from boreholes that are not metered.

The collection of these data will be of use in the future as certain coefficients may be established to estimate the volume of water used in agriculture, while the questionnaire and methodology may be useful to other EU Member States undertaking similar studies.

## 1.2 OBJECTIVE

The overall objective of the action is to obtain representative data on the volume of water used in the agricultural year 2008/2009 and to establish coefficients of the usage of water by crop and irrigation method that may be used for future analysis, including the Survey on Agricultural Production Methods (SAPM).

## 1.3 LEGAL FRAMEWORK

In Malta the legal basis for the collection of agricultural statistical data is the Malta Statistics Authority Act XXIV of 2000. This mandates the National Statistics Office to carry out any statistical survey and to compile official statistics. Extracts, from the Act, of the main functions of the office are:

Section 10
(2a) “to provide on an impartial basis, quantitative and representative information about the economic, demographic, gender issues, social and environmental situation in Malta, to all users including the Parliament, the Government, institutions, ….. ; where possible such data should be provided on a regional basis”.

(2b) “produce the data, and shall be subject to the principles of reliability, objectivity, relevance, statistical confidentiality, transparency, specificity and proportionality”.

(2c) “Supply the information necessary to evaluate the quality of official statistics and make accessible to the public the methods used for their production.”

Section 35
“The Director General may prepare forms, questionnaires and other records for the collection of information under this Act and the instructions necessary for their proper completion, and shall specify the date or period within which these completed forms, questionnaires and other records or the required information shall be returned to the Authority.”

All individual data collected during the survey are confidential. No data which might single out individual information may be published. Data collected through the survey is intended for statistical purposes only and may only be used for statistical publications, tables and analysis.

All persons engaged in the data collection, handling and processing of data are obliged to observe the confidentiality principle. The filling in of statistical questionnaires is compulsory under the Malta Statistics Authority Act.

### 1.4 LAUNCHING OF THE PROJECT

During 2007/2008, a draft Farm Structure Survey (FSS) regulation was discussed. It covered a new Survey on Agricultural Production Methods (SAPM) to be carried in 2010 in which Member States are to provide an estimation of the volume of water used for irrigation (in cubic metres) per agricultural holding. As in certain countries this was a difficult task, the Commission decided to provide Member States with financial support. In fact, in February 2008, the National Statistics Office (NSO) was awarded a grant from EUROSTAT to support a pilot survey to estimate the volume of water used for irrigation. Grant number 40701.2008.001-2008.130 was signed on the 8 July 2008.

### 1.5 PILOT SURVEY

In April 2008, a pilot survey was carried out on a small number of farmers to test the layout of the questionnaire and to identify any problems that may arise in the compilation of the data. As a result, a few alterations were needed to facilitate the data collection process and to ensure better understanding of the questionnaire from both the farmer's and the interviewer's point of view. From the survey, information on drips and sprinklers and on the amount of gallons applied using the various methods for irrigation was collected. These data were useful in the latter stages of the survey where certain imputations had to be made.

### 1.6 WORK PROCESS

The timetable of events is shown in Table 1.

**Table 1. Calendar of events for irrigation survey**

| Stage | Date |
|---|---|
| Questionnaire layout | Third Quarter 2008 |
| Sample design and selection | Third Quarter 2008 |
| Interviewing | September 2008 - September 2009 |
| Analysis | Fourth Quarter 2009 |
| Dissemination | First Quarter 2010 |

## 2. SURVEY METHODOLOGY

### 2.1 PREPARING THE SURVEY OPERATIONS

#### 2.1.1 Population and frame

The holding is the unit of enumeration while the parcel is the unit of observation. All the parcels on the holding were analysed, irrespective of whether the parcel was irrigated or not. The initial population eligible for participation in the irrigation survey amounted to 10,998 agricultural holdings, representing 9,597 hectares of utilised agricultural area. No thresholds for the survey were used.

The agricultural register is maintained by the Unit and is updated regularly through administrative sources and frequent surveys.

### 2.1.2 Survey design

The Unit opted for a stratified sample based on the typology of agricultural holdings and on the economic size class of the holding. The clustering of economic size class units (ESU) can be seen in Table 2.

**Table 2. Clustering of economic size class units**

| New ESU Clustered | Standard Gross Margins (€) |
|---|---|
| 1 | ≥0-<2400 |
| 2 | ≥2400-<9600 |
| 3 | ≥9600-<48000 |
| 4 | ≥48000 |

The Neyman optimum allocation method was applied to extract the sample. Due to the restricted sample size, no regional sampling was undertaken. All holdings included in the survey were extracted at NUTS I level.

To take into account seasonal effects, the sample was distributed into 26 batches, each having approximately 31 holdings and distributed to interviewers every fortnight. The survey was undertaken over a period of 52 weeks, from 15 September 2008 to 14 September 2009. The survey was designed so that consequent batches would overlap for a period of two weeks, increasing the representativeness of the overall sample. In this way, approximately 62 holdings were being interviewed at the same time. An extraction of the distribution of the first three batches is shown in Table 3.

**Table 3. Distribution of batches**

| Batch | 15 Sep. | 22 Sep. | 29 Sep. | 6 Oct. | 13 Oct. | 20 Oct. | 27 Oct. | 3 Nov. |
|---|---|---|---|---|---|---|---|---|
| 1 | Week 1 | Week 2 | Week 3 | Week 4 | | | | |
| 2 | | | Week 1 | Week 2 | Week 3 | Week 4 | | |
| 3 | | | | | Week 1 | Week 2 | Week 3 | Week 4 |

The distribution of the initial target population of agricultural holdings and the distribution of the sample extracted for this irrigation survey are given in Table 4.

**Table 4. Initial distribution of agricultural holdings by typology and size class of ESU**

| Stratum | TP Clustered | New ESU Clustered | Population | Sample | Weight |
|---|---|---|---|---|---|
| 1 | 141+2+3+6 | 1 | 4,716 | 104 | 45.346 |
| 2 | 141+2+3+6 | 2 | 2,287 | 153 | 14.948 |
| 3 | 141+2+3+6 | 3 | 720 | 220 | 3.273 |
| 4 | 141+2+3+6 | 4 | 42 | 42 | 1.000 |
| 5 | 1443+4+5+7+8 | 1 | 2,485 | 49 | 50.714 |
| 6 | 1443+4+5+7+8 | 2 | 363 | 27 | 13.444 |
| 7 | 1443+4+5+7+8 | 3 | 286 | 105 | 2.724 |
| 8 | 1443+4+5+7+8 | 4 | 99 | 99 | 1.000 |
| **Total** | | | **10,998** | **799** | |

In total, 799 agricultural holdings were selected from 8 strata. In order to maintain the number of surveyed holdings constant, any refusals were replaced immediately with another holding from the same stratum. Ideally, the new holding was chosen from the list of holdings having their land registered with the IACS department. In case a holding could no longer be replaced within a stratum, a correction factor was applied to the final weight of the stratum. The formula used for this adjustment is given below.

$$Wt_h = \frac{N_h}{n_h} \cdot \frac{n_h}{n_h^*}$$

where: $Wt_h$ is the weight applied to each holding surveyed in stratum *h*

$N_h$ is the population holdings in stratum *h*

$n_h$ is the initial number of holdings to be sampled in stratum *h*

$n_h^*$ is the actual number of holdings surveyed in stratum *h*

The IACS plans include the parcel number, the area and name of the parcel. This data could aid the farmer to easily identify what was grown in every parcel and whether the parcel was being irrigated or not. Previous surveys showed that this system of crop identification within each parcel reduced the interviewing time, reducing the overall burden in the data collection process.

The survey revealed that 51 agricultural holdings were not placed in the correct stratum and therefore if left in the stratum they were originally assigned to, the holdings would not have been given the appropriate weight. NSO decided to remove these holdings from their respective stratum, give them a weight of 1 and re-adjust the weights of the strata they were removed from. Such misplacements occur due to the fact that as the Census of Agriculture was undertaken in 2001, certain structural changes that took place could have not been updated in the agricultural register unless the holding was chosen in the previous survey.

Following this re-classification, the Unit adjusted the population frame as can be seen in Table 5.

**Table 5. Final distribution of agricultural holdings by typology and size class of ESU**

| Stratum | TP Clustered | New ESU Clustered | Population | Sample | Weight |
|---|---|---|---|---|---|
| 1 | 141+2+3+6 | 1 | 4,690 | 78 | 60.128 |
| 2 | 141+2+3+6 | 2 | 2,279 | 143 | 15.937 |
| 3 | 141+2+3+6 | 3 | 720 | 220 | 3.273 |
| 4 | 141+2+3+6 | 4 | 42 | 42 | 1.000 |
| 5 | 1443+4+5+7+8 | 1 | 2,468 | 32 | 77.125 |
| 6 | 1443+4+5+7+8 | 2 | 363 | 26 | 13.962 |
| 7 | 1443+4+5+7+8 | 3 | 286 | 105 | 2.724 |
| 8 | 1443+4+5+7+8 | 4 | 99 | 99 | 1.000 |
| 9 | 141+2+3+6 | | 34 | 34 | 1.000 |
| 10 | 1443+4+5+7+8 | | 17 | 17 | 1.000 |
| **Total** | | | **10,998** | **796** | |

The final sample of agricultural holdings for the Irrigation Survey amounted to 796 holdings, representing a response rate of 99.6 per cent.

### 2.2 TRAINING OF INTERVIEWERS

A detailed briefing at the NSO premises was held on 25 August 2008, in order to explain the questionnaire and the importance of the project. During the briefing session, all interviewers were provided with a detailed instruction manual on each characteristic of the survey and a list of farmers to be interviewed.

In order to avoid errors during the survey, all interviewers were instructed to interview not more than two holdings and return the booklets back to the Unit for an assessment to identify any mistakes undertaken during the interviewing stage. This exercise helped the interviewer to reduce the number of errors in the remaining questionnaires. This method, which was also used in other surveys, helped the Unit to reduce the total number of initial errors and thus lessen the processing time of a questionnaire.

### 2.3 DATA COLLECTION

Farmers were informed by mail approximately two weeks before the commencement of each batch, and were eventually interviewed individually by the enumerators. Enumeration started in the second week of September 2008 and was concluded by the end of September 2009. The questionnaire was split in two parts:

- First part related to the characteristics of the holding
  - Farmer's personal details;
  - List of parcels;
  - Area name;
  - Area under parcel (ha);
  - Soil type;
  - Crop code;

- Area under crop (ha);
- Irrigated or not;
- Notes;
- HP of pump;
- Flow Rate Gln/hr;
- Source;
- Irrigation type.

- Second part related to data collected weekly for a period of four weeks.
  - Starting date;
  - Irrigated last week or not;
  - Hours of irrigation;
  - Total Gallons;
  - % of crop watered.

Each interviewer received by email a list of the farmers to be interviewed in a particular period. The interviewers were to contact farmers for an appointment 10 days in advance of monitoring, to explain the data collection process and collect data for the first part of the questionnaire relating to the structure of the agricultural holding. Every week, each holding was contacted by the interviewer to record the volume of water used.

In the land parcels where drip irrigation was used, the farmer checked the length of the drip and the distance between each dripper in order to estimate the total number of drippers in the parcel used for a particular crop. The amount of water emitted by each dripper was calculated by recording the time in which a measuring jug was filled. The volume of water used in the respective parcel was then calculated by multiplying the amount of water delivered by each drip emitter, the total number of drippers and the total time the farmer spent irrigating the crop. When sprinklers were utilised, to estimate the volume of water used in each parcel, the farmer recorded the actual volume released from the reservoir during the time of irrigation.

Interviewers had to inform the Unit of any refusals at least five days prior to the starting date of the particular batch. This enabled the Unit to undertake any necessary changes. To carry out the replacement, the typology, ESU class, utilised agricultural area and the stratum of holding were also checked.

When the interviewers started returning the first set of questionnaires, the horse power of the pump and its respective flow rate in gallons per hour were not found to be relevant factors in the calculation of the volume of water. As a result, the Unit gave instructions to the interviewers to cease collecting these data. On the other hand, the Unit noticed that at the time of the survey, there existed the possibility that not all parcels would be sown (hereafter refereed to as 'temporarily empty'). For such cases, it was decided to include a new variable where the crop that was previously sown or that would be sown in the near future would also be recorded.

An in-house program for the Irrigation survey was developed by the IT Systems Unit within the NSO. All details were inputted within a few weeks after a completed batch was vetted and checked.

### 2.4 CONTROL OF THE DATA

Completed questionnaires were returned to the Unit as soon as the 4-week period elapsed. For each parcel of each holding, the Unit checked that the area under the parcel coincided with the area under the crops harvested. Moreover, from the volume of water given by the farmer, the Unit calculated the gallons of water used per hectare per hour. These values were checked against some averages that were obtained from the pilot survey. During the vetting process, any queries that arose were clarified immediately with the interviewer. In some cases, the farmer was contacted again by NSO staff to verify the data, and in some cases the amount of water used was corrected.

In cases where the farmers were not able to record the total amount of gallons of water used, NSO officials imputed the missing data. These values were imputed by the average number of gallons per hectare per hour according to the method of irrigation used.

For each batch, once all questionnaires were vetted and inputted, the process continued by checking the data for any data inputting errors. At this stage, all the information was checked for any outliers and where needed, data were confirmed with the farmers. When the latter stage was completed, the Unit

started to analyse the data in order to build a model that could estimate the volume of water used for irrigation purposes in successive periods.

A copy of the questionnaire may be found in the Annex.

### 2.5 DIFFICULTIES AND LIMITATIONS ENCOUNTERED

The data collection process is by no means an easy task. In Malta, farmers are not obliged to have a water meter and therefore the first problem encountered was that a number of farmers did not keep any records of how much water was being consumed for irrigation. This presented some problems in obtaining accurate information and had an effect on the average time the interviewer spent at the holding.

Malta being a small country, it is very difficult for NSO to extract a reliable sample on any statistical domain if the large holdings are not exhaustively surveyed. Due to the limited amount of holdings, these are therefore always included in the sample. These farmers are also contacted to take part in the data collection process of other statistical domains, such as business, labour force and other domains. This can result in a burden on farmers.

In order to increase the accuracy and reliability of the data, ideally the sample should have covered 799 holdings every four weeks. Whereas budgetary constraints limit the actual sample size, human resource limitations is an issue when conducting surveys of a highly technical nature. These surveys require skilled human resources, which in some cases national statistical institutes do not have.

### 2.6 COST OF THE SURVEY

**Table 6. Expenses incurred in survey implementation**

| | Budgeted expenditure | Actual expenditure |
|---|---|---|
| | € | € |
| **Total** | **37,862.70** | **30,289.29** |
| Staff Costs | 28,119.70 | 25,869.35 |
| *Permanent Staff* | *8,119.70* | *12,857.35* |
| *Temporary Staff* | *20,000.00* | *13,012.00* |
| Travel/Subsistence Costs | 7,266.00 | 2,438.40 |
| Sub-contracting | - | - |
| Other Direct Costs | - | - |
| Eligible Indirect Costs (7%) | 2,477.00 | 1,981.54 |

## 3. EVALUATION OF RESULTS

Table 7 illustrates the distribution of the utilised agricultural area as revealed by the survey. The total utilised agricultural area amounted to 10,006.6 hectares, of which 2,635.4 hectares were found to be temporarily empty when the farmer was interviewed. The cultivated area refers to the agricultural area that was physically cultivated during the interviewing period. The second column in Table 7, referred to as future/past crop, referred to how temporarily-empty parcels during the reference weeks were cultivated during the crop year 2008/2009. To obtain this information, the farmer was requested to

provide information on what crop was either harvested prior to the survey date or what crop would be sown after the four-week period. Coinciding with the results of previous surveys in the field of agricultural statistics, the area cultivated with forage plants amounted to 4,791.5 hectares. The distribution of irrigated area by crop is presented in Table 8. This area accounts for 28.9 per cent of the total area surveyed.

**Table 7. Distribution of land (ha)**

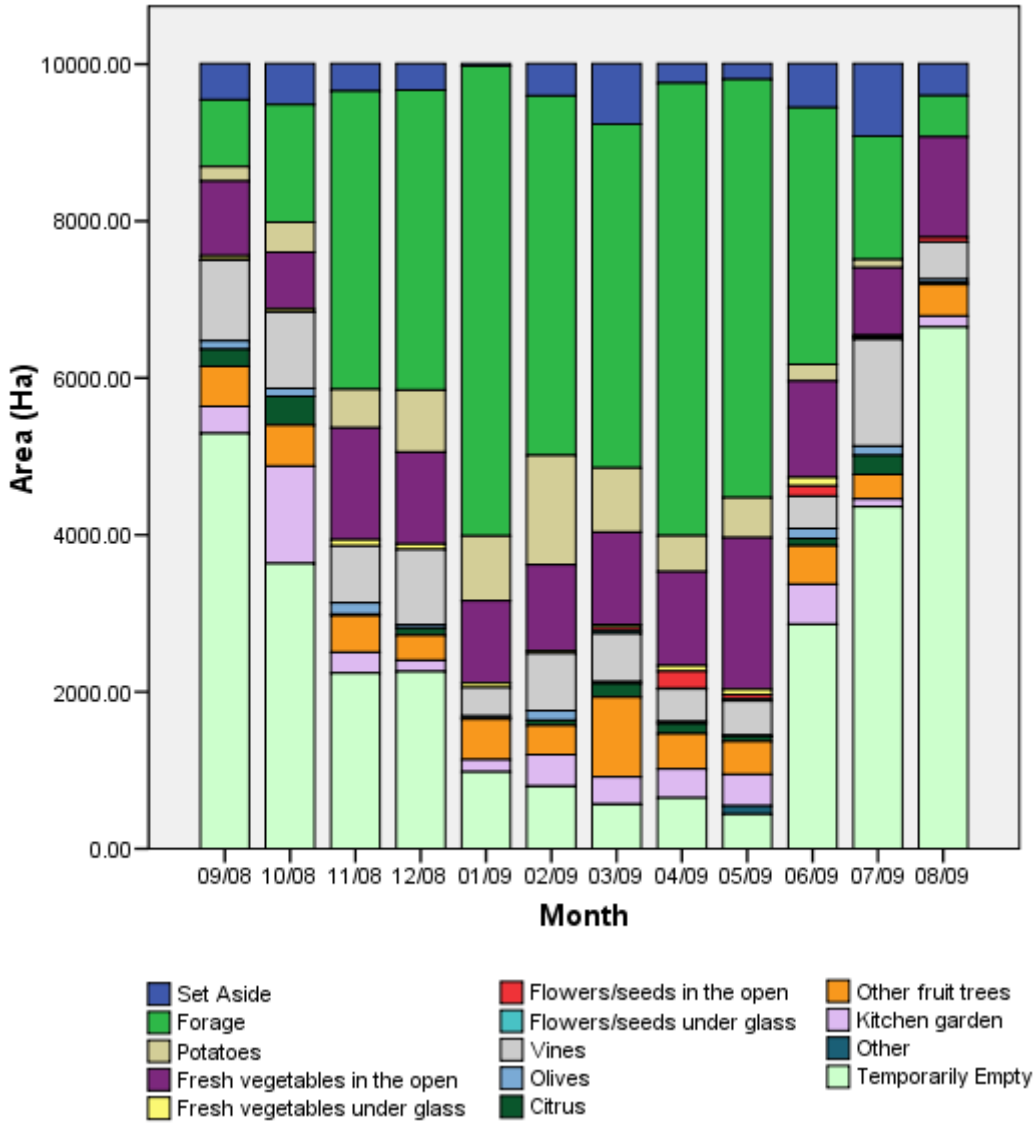
| | Cultivated area (ha) | Future/Past Crop (ha) | Total area (ha) |
|---|---|---|---|
| **Total** | **7,371.2** | **2,635.4** | **10,006.6** |
| Potatoes | 509.3 | 299.4 | 808.7 |
| Fresh vegetables in the open | 1,156.1 | 806.0 | 1,962.1 |
| Plants and flowers in the open | 42.2 | 11.2 | 53.4 |
| Fresh vegetables under glass | 53.6 | 15.2 | 68.8 |
| Plants and flowers under glass | 7.4 | 0.5 | 7.9 |
| Set-aside | 433.8 | 0.6 | 434.4 |
| Forage | 3,360.4 | 1,431.1 | 4,791.5 |
| Vines | 725.2 | - | 725.2 |
| Citrus fruit | 133.0 | - | 133.0 |
| Olives | 74.9 | 1.7 | 76.6 |
| Other fruit trees | 489.6 | 12.3 | 501.9 |
| Kitchen garden | 377.4 | 57.4 | 434.8 |
| Other | 8.2 | - | 8.2 |

**Table 8. Irrigated areas (ha) surveyed**

| | Irrigated area (ha) | Irrigated Future/Past Crop (ha) | Total Irrigated area (ha) |
|---|---|---|---|
| **Total** | **2,161.9** | **729.5** | **2,891.4** |
| Potatoes | 351.7 | 192.6 | 544.3 |
| Fresh vegetables in the open | 618.9 | 499.0 | 1,117.9 |
| Plants and flowers in the open | 12.9 | 8.6 | 21.5 |
| Fresh vegetables under glass | 52.9 | 15.0 | 67.9 |
| Plants and flowers under glass | 7.4 | 0.5 | 7.9 |
| Vines | 456.6 | - | 456.6 |
| Citrus fruit | 120.9 | - | 120.9 |
| Olives | 46.7 | - | 46.7 |
| Other fruit trees | 271.4 | - | 271.4 |
| Kitchen garden | 222.3 | 13.8 | 236.1 |
| Other | 0.2 | - | 0.2 |

The weighted area of the holdings within the respective batch had to be further grossed up to represent the total agricultural area. To obtain the monthly distribution of the total agricultural area, a grossing-up factor was used. This was calculated by dividing the total agricultural area (10,006 hectares) by the monthly weighted area. Chart 1 displays the distribution of the total agricultural area each month.

**Chart 1. Agricultural area under crop as per holdings sampled each month**




From Chart 1, it can be clearly noted that the distribution of the cultivated crops follows a rather seasonal pattern throughout the crop year. As forage (amounting to 47.9 per cent of all agricultural area) is a winter crop, the graph shows that it starts to be sown in September, and almost all the area would be harvested by August. As one would expect, the temporarily-empty area decreases gradually throughout the crop year and starts increasing again during the summer months, when most of the crops would be harvested.

## 4. ESTIMATING THE VOLUME OF WATER USED FOR IRRIGATION

To calculate the volume of water used, an Analysis of Covariance (ANCOVA) regression model was fitted, using the Statistical Package for the Social Sciences (SPSS). The model is provided with essential information related to irrigated area, type of irrigation and climatological data obtained from the Meteorological Office at the Malta International Airport on a daily basis. This will enable the model to predict the total volume of water used. Climatological data included average daily temperature, relative humidity and wind speed, and daily amount of rain in millimetres. Since the volume of water used for irrigation is highly dependent upon these climatological data, the information collected from farmers was directly linked with the average temperature, relative humidity and wind speed, and the total amount of rain **on a weekly basis** in respect of the week in which the farmer was interviewed. The aggregation of all data was used in SPSS to fit the above-mentioned model.

ANCOVA is the name given to a linear regression model when the predictors include a combination of covariates (quantitative predictors) and factors (qualitative predictors). In this model temperature, rain, relative humidity and wind speed are covariates whereas type of crop and irrigation method are factors. These predictors are all included as main effects in the model fit. The number of gallons per hectare is the dependent variable and is assumed to have a normal distribution.

Table 9, displaying tests of between-subject effects, reveals that temperature is the best predictor of the amount of water required for irrigation. This is followed by precipitation, irrigation method, type of crop, wind speed and crop area. Relative humidity least affect the volume of water needed for irrigation per hectare. This ANCOVA regression model, that includes all main effects, explains 27.3 per cent of the total variability in the amount of water used for irrigation.

**Table 9. Tests of between-subjects effects**

Dependent Variable: Gallons per Hectare

| Source | Type III Sum of Squares | df | Mean Square | F | P-value |
|---|---|---|---|---|---|
| Type of Crop | $1.57 \times 10^{12}$ | 10 | $1.57 \times 10^{11}$ | 76.419 | .000 |
| Irrigation Type | $9.47 \times 10^{11}$ | 4 | $2.37 \times 10^{11}$ | 115.103 | .000 |
| Temperature | $9.19 \times 10^{11}$ | 1 | $9.19 \times 10^{11}$ | 446.491 | .000 |
| Precipitation | $2.84 \times 10^{11}$ | 1 | $2.84 \times 10^{11}$ | 138.137 | .000 |
| Relative Humidity | $6.91 \times 10^{9}$ | 1 | $6.91 \times 10^{9}$ | 3.360 | .067 |
| Wind Speed | $5.01 \times 10^{10}$ | 1 | $5.01 \times 10^{10}$ | 24.334 | .000 |
| Crop Area | $2.17 \times 10^{10}$ | 1 | $2.17 \times 10^{10}$ | 10.528 | .001 |

R Squared = .273 (Adjusted R Squared = .271)

To fit an ANCOVA regression model, dummy variables are generated to accommodate categorical variables. Table 10 displays the parameter estimates indicating the aliased terms.

**Table 10. Parameter estimates**

| Model term | Parameter estimates |
|---|---|
| Intercept | 2,414.686 |
| [Crop=Potatoes] | -66,008.765 |
| [Crop=Fresh Vegetables in the open] | -59,728.505 |
| [Crop=Fresh Vegetables under Glass] | -43,908.339 |
| [Crop=Flowers/Seeds in the open] | -17,976.815 |
| [Crop=Flowers/Seeds under Glass] | -14,075.908 |
| [Crop=Vines] | -99,968.002 |
| [Crop=Olives] | -95,866.172 |
| [Crop=Citrus] | -88,703.166 |
| [Crop=Other fruit trees] | -90,622.018 |
| [Crop=Kitchen Garden] | -63,988.717 |
| [Crop=Other] | Aliased |
| [Irrigation Type=Drip] | 17,543.841 |
| [Irrigation Type=Sprinkler] | 49,213.899 |
| [Irrigation Type=Surface Irrigation] | 8,395.647 |
| [Irrigation Type=Rain gun] | 12,110.809 |
| [Irrigation Type=Other] | Aliased |
| Temperature | 3,964.294 |
| Precipitation | -390.277 |
| Relative Humidity | -177.488 |
| Wind Speed | 1,597.646 |
| Crop Area | 5,885.287 |

Aliased: Parameter set to 0

The parameter estimates comply to what is expected. The parameter estimates for temperature, wind speed and crop area are all positive values, implying that an increase in temperature, wind speed and crop area will significantly increase the volume of water needed for irrigation. On the other hand, the parameter estimates for precipitation and humidity are negative values implying that less water is required with an increase in precipitation and humidity. The relationship that estimates the volume of water used for irrigation (in gallons per hectare) using crop, area and climatological data is given by:

$$\text{Estimated weekly volume of water per hectare} = I_0 + C + I + T\left(\text{Average Temperature}\right) + P\left(\text{Weekly Precipitation}\right) + H\left(\text{Average Humidity}\right) + W\left(\text{Average Windspeed}\right) + CA\left(\text{Average Area}\right)$$

where: $I_0$ is the intercept

$C$ is the parameter estimate for the type of crop

$I$ is the parameter estimate for the type of irrigation

$T$ is the parameter estimate for the temperature

$P$ is the parameter estimate for the precipitation

$H$ is the parameter estimate for the humidity

$W$ is the parameter estimate for the wind speed

$CA$ is the parameter estimate for the crop area

The mean temperature, mean relative humidity and mean wind speed were computed by averaging daily observations over the whole year. On the other hand, precipitation was computed by averaging weekly total rainfall over a whole year. These averages are displayed in Table 11.

**Table 11. Climatological data**

| | 2008/2009 |
|---|---|
| Temperature ($^{o}$C) | 19.180 |
| Relative Humidity | 71.910 |
| Mean Wind Speed (Knots) | 7.413 |
| Precipitation (in mm) | 16.412 |

The climatological data, presented in Table 11, the relevant information related to irrigation methods for each crop, presented in Table 12, and the parameters estimated by SPSS were used to estimate the weekly volume of water (in gallons) required per hectare for each combination of crop type and irrigation method.

**Table 12. Combination of crop and irrigation type**

| Crop | Drip | Sprinkler | Surface Irrigation | Rain gun | Other |
|---|---|---|---|---|---|
| Potatoes | ✓ | ✓ | ✓ | ✓ | ✓ |
| Fresh vegetables in the open | ✓ | ✓ | ✓ | ✓ | ✓ |
| Fresh vegetables under glass | ✓ | ✓ | | | |
| Plants and flowers in the open | ✓ | ✓ | ✓ | | |
| Flowers/Seeds under glass | ✓ | | | | ✓ |
| Vines | ✓ | | ✓ | | |
| Olives | ✓ | | ✓ | | |
| Citrus | ✓ | | ✓ | | ✓ |
| Other fruit trees | ✓ | | ✓ | | ✓ |
| Kitchen Garden | ✓ | ✓ | ✓ | ✓ | ✓ |
| Other | | ✓ | | | |

The volume of water required for each combination of crop type and irrigation method was then multiplied by the corresponding actual irrigated area and further multiplied by 52 weeks to obtain the yearly volume of water used for irrigation.

The total estimated volume of water used yearly was computed by aggregating the volume of water for all the combinations listed above. The regression model yielded an estimate of 4.2 billion gallons of irrigation water yearly (19.1 million cubic metres yearly).

### 4.1 VALIDATION OF MODEL

Model validation is essential in the model building sequence. To validate the model, it was decided to calculate the volume of water used for irrigation from the collected data to compare the result of the survey data to the estimates arising from the model. It is a known fact that not all parcels of agricultural land are cultivated during the whole year. Therefore during the interviewing stage, the farmers were asked about the parcels in which crops were sown as well as about those parcels that were temporarily empty. Out of all sown parcels, those that were irrigated were noted. For the temporarily-empty parcels, the crops that the farmer would sow in the forthcoming months or the crops that the farmer had cultivated in the previous months were recorded. In respect of the latter parcels, the amount of water used for irrigation was unknown, and thus had to be estimated. The following procedure was applied. Taking into consideration the irrigated parcels only, for each type of crop, the average gallons per hectare per hour and the average weekly hours of irrigation were extracted. In addition, the average number of weeks throughout which the crop would be irrigated for a period of one year were provided by the research institute. These are shown in Table 13.

**Table 13. Duration of irrigated crop in months and weeks**

| Crop | Months | Weeks |
|---|---|---|
| Potatoes | 7 | 28 |
| Fresh vegetables in the open | 9 | 36 |
| Fresh vegetables under glass | 9 | 36 |
| Plants and flowers in the open | 7 | 28 |
| Flowers/Seeds under glass | 5 | 20 |
| Vines | 4 | 16 |
| Olives | 5 | 20 |
| Citrus | 8 | 32 |
| Other fruit trees | 6 | 24 |
| Kitchen Garden | 6 | 24 |
| Other | 12 | 52 |

To estimate the volume of water that farmers use for these temporarily-empty parcels, the calculation for each temporarily-empty parcel included the multiplication of the total amount of hours that the crop needed for irrigation, the average gallons per hectare per hour, and the area under crop. This was done by applying the mathematical formulae below.

$$\text{Total hours of Irrigation} = \text{Average hours of irrigation per crop} \times \text{Duration in weeks per crop}$$

$$\text{Gallons for each parcel} = \text{Average gallons per hectare per hour} \times \text{Total hours of irrigation} \times \text{Area under crop}$$

To estimate the overall volume of water, the estimated volume of water used for these temporarily-empty parcels was added to the volume of water given by the farmers. The total volume of water used for irrigation for the crop year 2008/2009 amounted to 4.1billion gallons or 18.7 million cubic metres. When comparing the survey method to the model, a 1.7 per cent variation resulted, ensuring the overall validity of the model.

## 5. PUBLICATION AND DISSEMINATION

A press conference disseminating the final results of the irrigation survey in Malta will take place in Spring 2010. The tables presented will include information on the structure of the area surveyed, total irrigated area and the volume of water used for irrigation.

These results will also be available on the National Statistics Office website in PDF-format.

# ANNEX

NATIONAL STATISTICS OFFICE • MALTA

# Irrigation

## KUNFIDENZJALI WARA LI JIMTELA
*CONFIDENTIAL AFTER FILLED IN*

| Ibdel fejn japplika *Change where applicable* | | |
|---|---|---|
| | NSO Reference | |
| | Isem u Kunjom *Name & Surname* | |
| | Dar Nru / Isem *House No / Name* | |
| | Triq *Street* | |
| | Lokalita *Locality* | |

| | |
|---|---|
| Interviewer ID | |
| Date | |
| Signature | |

**Booklet** ☐ of ☐

| | D | D | M | M | Y | Y | Y | Y |
|---|---|---|---|---|---|---|---|---|
| From | | | | | 2 | 0 | 0 | |
| To | | | | | 2 | 0 | 0 | |

# Stħarriġ dwar it-tisqija fl-agrikoltura
# 15 ta' Settembru 2008 – 14 ta' Settembru 2009

## Kwestjonarju

## *Survey on Irrigation*
## *15th September 2008 – 14th September 2009*

## Questionnaire

**It-tagħrif qiegħed jintalab bis-setgħa ta' l-Att XXIV ta' l-2000 li waqqaf l-Awtorita ta' l-Istatistika ta' Malta.**
**Din l-informazzjoni tintuża biss għal skop ta' ġbir ta' statistika u analiżi.**
**Hemm kontemplati penalitajiet amministrattivi f'każ ta' nuqqas ta' koperazzjoni u dikjarazzjonijiet foloz**

Supply of data is compulsory under the Malta Statistics Authority Act XXIV 2000.
Data will be used for statistical purposes only.
Refusal or false declarations may incur penalties.

Persuna ta' Riferenza
*Reference Person*

Firma
*Signature*

☐☐☐☐☐☐☐☐
Nru Karta ta' l-Identità
*Id Card No*

☐☐☐☐☐☐☐☐
Nru Tel
*Tel No.*

☐☐☐☐☐☐☐☐
Nru Mobile
*Mobile No.*


***Agriculture and Fisheries Unit***
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*agric.nso@gov.mt, http://www.nso.gov.mt*

| No. | Parcel Number | Area Name | Area under parcel (ha) | Soil type[a] | Crop Code[b] | Area under crop (ha) | Irr. (✓) | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
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| 24 | | | | | | | | |
| 25 | | | | | | | | |
| 26 | | | | | | | | |

[a]Soil type

1 Tafli
2 Hamri
3 Bajjad
4 Hirbi
5 Other

[b]Crop Codes

1 Set aside
2 Non-Agric. Land
3 Forage
4 Potatoes
5 Fresh Veg – Open
6 Fresh Veg - Glass
7 Flowers/Seeds - Open
8 Flowers/Seeds - Glass
9 Vines
10 Olives
11 Citrus
12 Other fruit trees
13 Kitchen Garden

| | | | | | Week 1 - starting on (DD/MM/YYYY) ___/___/___ | | | |
|---|---|---|---|---|---|---|---|---|
| No. | HP of Pump | Flow Rate Gln/hr | Source [c] | Irrigation Type[d] | Irrigated last week (✓) | Hours | Total Gallons | % of crop watered |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
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| 24 | | | | | | | | |
| 25 | | | | | | | | |
| 26 | | | | | | | | |

[c]Source

1 Giebja/Gibjun
2 Borehole dirett
3 Bowser dirett

[d]Irrigation type

1 Drip
2 Sprinkler
3 Pipe
4 Other

| Week 2 - starting on (DD/MM/YYYY) ___/___/__ | | | | |
|---|---|---|---|---|
| No. | Irrigated last week (✓) | Hours | Total Gallons | % of crop watered |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
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| 25 | | | | |
| 26 | | | | |

| Week 3 - starting on (DD/MM/YYYY) ___/___/__ | | | | |
|---|---|---|---|---|
| No. | Irrigated last week (✓) | Hours | Total Gallons | % of crop watered |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
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| 25 | | | | |
| 26 | | | | |

| Week 4 - starting on (DD/MM/YYYY) ___/___/__ | | | | |
|---|---|---|---|---|
| No. | Irrigated last week (✓) | Hours | Total Gallons | % of crop watered |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
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## Remarks