

**GROSS NITROGEN BALANCE
FOR MALTA
2007**

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SUMMARY

This is the first comprehensive survey on the calculation of the Gross Nutrient Balance in Malta and Gozo. The survey covered the agricultural year from September 2006 to August in 2007. Information on fertiliser usage was collected from a stratified sample of farmers and growers across Malta and Gozo with holdings larger than 0.2 ha, and the data collected was raised using the agricultural register, to give national estimates of fertiliser usage. In order to calculate the Gross Nitrogen Balance, estimates on the nitrogen uptake per hectare of the selected crops were obtained.

Eleven crops were included in the survey: forage, potatoes, onions, carrots, tomatoes, vegetable marrows, sugar melons and water melons, grapes, peaches and citrus crops. Greenhouse vegetables were also included. These crops contributed to over 85% of the utilised agricultural area and to 90% of the production of fruit and vegetables in Malta and Gozo.

The Gross Nitrogen Balance for Malta was estimated at being 117 kg/N per hectare, approximately two and a half times the median of Gross Nitrogen Balances for EU Member states at 47 kg/N per hectare.

1. INTRODUCTION

1.1 HISTORY AND SCOPE

Natural and mineral fertilisers have been used in the agricultural sector for a number of years. As a consequence of their usage, environmental pressures are on the increase for a reduction in the use of fertilisers. These past years a growing awareness among the general public to monitor their usage has been evident.

Pressures on demand for greater agricultural production have, perhaps, brought about greater use of fertilisers. This exercise is intended to quantify usage of fertilisers in Maltese agricultural practices and to estimate the Gross Nitrogen Balance.

The survey on nutrient balances estimates the potential surplus of nitrogen on agricultural land. This is done by calculating the balance between nitrogen entering into the agricultural system and nitrogen removed from the system. Whereas the nitrogen entering the agricultural system consists of the amount of nitrogen applied through mineral fertilisers and manure, the output of nitrogen is contained in the crops harvested. The balance, if any is the remainder of nitrogen in the agricultural system.

1.2 BACKGROUND

In Malta, the lack of accurate data concerning fertiliser use has been recognised as the most important obstacle to measuring the risks linked to fertilisers under the two EU Directives; the Nitrates Directive (91/676/EC) and the Water Framework Directive (2000/60/EC). Measurements of risks related to the use of fertilisers need appropriate indicators and therefore, Member States, the Commission and the OECD, have conducted studies for their establishment.

The Nitrates Directive (Council of the European Communities, 1991) has the general purpose of "reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution" (Art.1). A threshold nitrate concentration of 50 mg/l is set as the maximum permissible level, and the Directive limits applications of livestock manure to land to 170 kg N/ha/yr. The Water Framework Directive (Council of the European Communities, 2000) requires all inland and coastal waters to reach "good status" by 2015. Good ecological status is defined in terms of the quality of the biological community, hydrological characteristics and chemical characteristics. The Sixth environmental action programme (European Commission, 2001), encourages the full implementation of both the Nitrates and Water Framework Directives, in order to achieve levels of water quality that do not give rise to unacceptable impacts on, and risks to, human health and the environment.

In Malta, statistics on fertilisers brought into the country, whether from other EU states or 3rd countries are collected by the International Trade Section within the National Statistics Office. No empirical studies on actual consumption of fertilisers have ever been conducted by the National Statistics Office (NSO) or the Ministry for Resources and Rural Affairs (MRRA).

1.3 LAUNCHING OF THE PROJECT

The first contact on the subject was made during the CPSA meeting held in 2006 where projects under the TAPAS action plan for 2007 were discussed. Mr. Mario Vella, Manager of Agriculture and Fisheries at the time, seized the opportunity to undertake a Nutrient Balance survey under the TAPAS action plan. The Agriculture and Fisheries Unit undertook a set of meetings with officials specialising in the use of fertilisers within the Ministry for Resources and Rural Affairs in order to explore and integrate the available data. In order to calculate the Nutrient Balances, a specific questionnaire was designed.

1.4 LEGAL FRAMEWORK

In Malta the legal basis for the collection of agricultural statistical data is the Malta Statistics Authority Act No XXIV, enacted in the year 2000. This places full responsibility on the National Statistics Office to carry out

any statistical survey and to produce 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 is 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 keep the confidentiality. The filling in of statistical questionnaires is compulsory, under the Statistics Act.

2 CONTENT

2.1 OBJECTIVE OF THE PROJECT

Nutrient or mineral balances provide insight into links between agricultural nutrient use, changes in environmental quality, and the sustainable use of soil nutrient resources. A persistent surplus indicates potential environmental problems; a persistent deficit indicates potential agricultural sustainability problems. With respect to environmental impacts, however, the main determinant is the absolute size of the nutrient surplus/deficit linked to local farm nutrient management practices and agro-ecological conditions, such as soil type and weather patterns (rainfall, vegetation period etc.).

The gross nutrient balance for nitrogen provides an indication of potential water pollution and identifies those agricultural areas and systems with very high nitrogen loadings. As the indicator integrates the most important agricultural parameters with regard to potential nitrogen surplus it is currently the best available measure for nutrient leaching risk.

The need for complete, reliable and comparable statistics on fertilisers and Nutrient Balances at EU level will help the Commission to implement and prepare EU policy on the use of fertilisers.

Records on the importation of fertilisers are kept by the 'International Trade Section' within the NSO but are only kept at CN Code level. The net weight by CN Code is also available. However, this does not reflect the usage on particular crops, hence, the necessity to carry out an empirical study is essential. In Malta, there are only a handful of importers who are involved in fertiliser trade.

The survey was conducted to establish information on the amounts of fertilisers consumed on the major crops cultivated in Malta. Such information is vital if potential risks to consumers, workers and the environment are to be monitored with the aim of reducing them. The survey aimed to establish the extent of fertilisers through a fully stratified sample of farmers.

Through this survey the NSO will be able to estimate the consumption of fertilisers used in the agricultural year 2006/07, in particular nitrogen containing fertilisers. Finally, the Gross Nitrogen Balance will be

estimated. This value will serve as a baseline figure for which future measurements through similar studies may be compared.

3 SURVEY METHODOLOGY

3.1 PREPARING THE SURVEY OPERATIONS

3.1.1 Population and frame

Due to the importance of nitrogen balances, the NSO decided to carry out a full-scale sample survey on the major crops cultivated on the Maltese Islands. These crops surveyed in this report covered 80 per cent of the total crop area. Crop areas of negligible importance were disregarded for the survey. It was foreseen as too complicated to obtain precise information on these areas. Budgetary constraints also played an important role in determining the sample and thus the sample size had to be restricted.

The Agriculture and Fisheries Unit conducted an agricultural census in 2001 with no thresholds being applied. A complete overview of the sector was obtained from the Census. The agricultural register is maintained and updated regularly with other surveys and administrative sources and at the time of selection the agricultural register had a total of 11,039 agricultural holdings with a total of 9,412 ha of utilised agricultural area.

In order to eliminate the very small agricultural holdings from the survey, agricultural holdings with a utilised agricultural area of less than 0.2 ha were excluded from the target population. These areas are mainly used for self-production and are not considered commercial. The use of fertilisers on these areas was considered negligible and also because it would have been very difficult to obtain certain information on areas producing crops for self-consumption. With this in mind, 2,422 agricultural holdings were excluded from the sample whose combined area totalled 244.1 ha, or on average 0.1 ha per holding. Although these holdings account for 21.9 per cent of the agricultural register, they only have 2.6 per cent of the total utilised agricultural area in Malta and Gozo.

The sample design for this survey contained 8 strata as can be seen in table 1.

Table 1. Initial distribution of strata by size class of UAA (ha) and typology

Typology	Size class of UAA (ha)			
	≥ 0.2 - < 1	≥ 1 - < 3	≥ 3 - < 5	≥ 5
1,4,5,7,8	Stratum 1	Stratum 2	Stratum 3	Stratum 4
2,3,6	Stratum 5	Stratum 6	Stratum 7	Stratum 8

Due to the restricted sample size and also due to the variation in sizes of UAA no regional sampling was undertaken. All holdings included in the survey were extracted at NUTS 1 level. In order to increase precision estimates, stratification was undertaken at the principal level of typology and size classes of the utilised agricultural area.

The distribution of the initial target population of agricultural holdings that were covered by the survey is given in Table 2 below. A striking feature about Maltese agriculture is that the majority of agricultural holdings above the threshold are still relatively small, as illustrated in Chart 1, where 67.4 per cent of the target population have a holding size of between 0.2 hectare and 1 hectare of utilised agricultural area. Only 1.8 per cent of the target population are considered large holdings, having 5 a utilised agricultural area of 5 hectares or more. In between, 2,302 agricultural holdings have a utilised agricultural area between 1 and 3 hectares, while 383 agricultural holdings have a utilised agricultural area between 3 and 5 hectares.

Table 2. Distribution of agricultural holdings by size class of UAA (ha) and typology

Typology	Size class of UAA (ha)				TOTAL
	$\geq 0.2 - < 1$	$\geq 1 - < 3$	$\geq 3 - < 5$	≥ 5	
1,4,5,7,8	2,113	765	110	44	3,032
2,3,6	3,696	1,533	243	113	5,585
TOTAL	5,809	2,298	353	157	8,617
% of Total	67.4%	26.7%	4.1%	1.8%	100.0%

Chart 1. Percentage distribution of agricultural holdings by size class of UAA (ha)

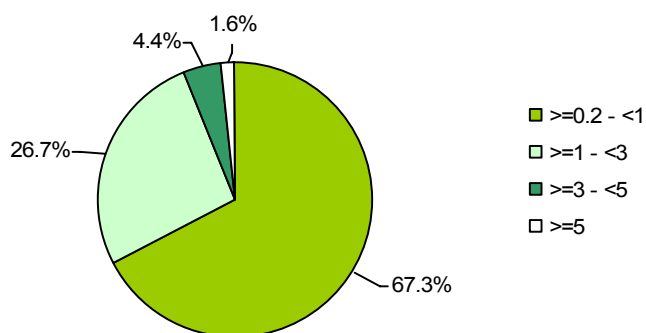
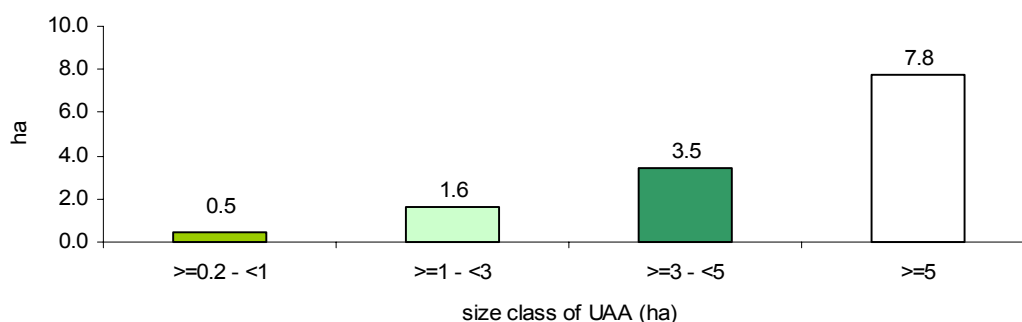


Chart 2. Average holding size (ha) by size class of UAA (ha)



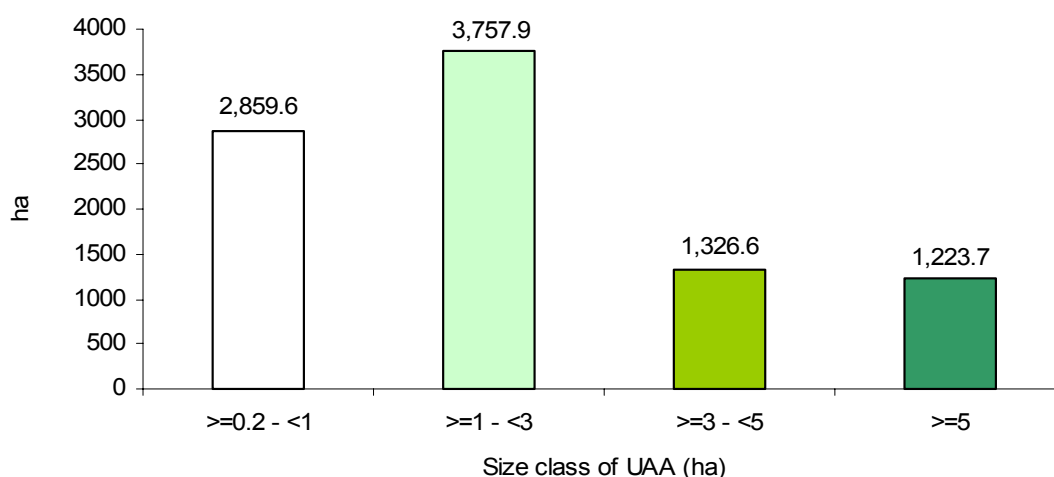
The distribution of the utilised agricultural area of the initial target population in Malta is somewhat different and this can be seen in Table 3. 31.2 per cent of the UAA above the threshold is accounted for by 5,809 holdings having between 0.2 and 1 ha, with an average holding size of 0.5 ha. Agricultural holdings with an agricultural area of 5 hectares and above make up 13.3 per cent of the total agricultural area. The average holding size of these holdings is 7.8 hectares.

In order to reduce the variability of the largest holdings, all agricultural holdings in Stratum 4 and Stratum 8 were to be exhaustively surveyed as these holdings were considered large.

Table 3. Distribution of UAA (ha) by size class of UAA (ha) and typology

Typology	Size class of UAA (ha)				TOTAL
	≥ 0.2 - < 1	≥ 1 - < 3	≥ 3 - < 5	≥ 5	
1,4,5,7,8	1,021.4	1,230.9	401.2	402.2	3,055.8
2,3,6	1,838.2	2,527.0	925.4	821.5	6,112.1
TOTAL	2,859.6	3,757.9	1,326.6	1,223.7	9,167.9
% of Total	31.2%	41.0%	14.5%	13.3%	100.0%

Chart 3. Distribution of UAA (ha) by size class of UAA (ha)



3.1.2 Survey design

The agriculture and fisheries unit opted for a stratified sample based on the typology of agricultural holdings at the time and also on the size of the utilised agricultural area of the holding. The Neyman optimum allocation method was utilised to extract the sample as this was seen as the best method to obtain a representative sample. This method was seen as the most appropriate as more holdings were chosen from strata with a greater degree of variability.

Table 4 shows the initial sample distribution of agricultural holdings to be surveyed. From Table 4, 33.4 per cent of all holdings were to be surveyed from strata 1 and 5, while 32.8 per cent of all holdings were to be surveyed from strata 2 and 6. These 4 strata contained the most variability and thus the majority of agricultural holdings were chosen from these strata. The greatest variability was noticed in strata 4 and 8, and thus all holdings were sampled.

Table 4. Initial sample distribution of holdings by size class of UAA (ha) and typology

Typology	Size class of UAA (ha)				TOTAL
	≥ 0.2 - < 1	≥ 1 - < 3	≥ 3 - < 5	≥ 5	
1,4,5,7,8	66	59	9	44	178
2,3,6	118	122	20	113	373
TOTAL	184	181	29	157	551

Table 5. Percentage initial distribution of holdings by size class of UAA (ha) and typology

Typology	Size class of UAA (ha)				TOTAL
	≥ 0.2 - < 1	≥ 1 - < 3	≥ 3 - < 5	≥ 5	
1,4,5,7,8	12.0%	10.7%	1.6%	8.0%	32.3%
2,3,6	21.4%	22.1%	3.6%	20.5%	67.7%
TOTAL	33.4%	32.8%	5.2%	28.5%	100.0%

From the survey, it was found that certain agricultural holdings were misplaced. The main reason for this was that as the Census of Agriculture was undertaken 8 years ago certain structural changes would have taken place and these changes would not have been updated in the agricultural register. All the NSO maintains and updates the agricultural register certain agricultural holdings may only be updated after a specific survey would have taken place. If these holdings are never chosen to be part of a survey, then it is impossible to identify these holdings from beforehand. Only after the survey has taken place will the NSO be in a position to place these holdings in the appropriate stratum.

In order to take into consideration this problem, the agriculture and fisheries unit adjusted the population frame as can be seen in Table 6 below.

Table 6. Adjusted target population of agricultural holdings by size class of UAA (ha) and typology

Typology	Size class of UAA (ha)				TOTAL
	≥ 0.2 - < 1	≥ 1 - < 3	≥ 3 - < 5	≥ 5	
1,4,5,7,8	2,107	768	116	41	3,032
2,3,6	3,687	1,526	275	97	5,585
TOTAL	5,794	2,294	391	138	8,617

The final sample distribution of agricultural holdings for the Gross Nitrogen Balance Survey amounted to 513 holdings split over 8 strata. This amounted to a total response rate of 93.1 per cent.

Table 7. Final sample distribution of holdings by size class of UAA (ha) and typology

Typology	Size class of UAA (ha)				TOTAL
	≥ 0.2 - < 1	≥ 1 - < 3	≥ 3 - < 5	≥ 5	
1,4,5,7,8	41	72	14	37	164
2,3,6	73	138	54	84	349
TOTAL	114	210	68	121	513

Table 8. Weighting structure of holdings by size class of UAA (ha) and typology

Typology	Size class of UAA (ha)				TOTAL
	≥ 0.2 - < 1	≥ 1 - < 5	≥ 3 - < 5	≥ 5	
1,4,5,7,8	51.390	10.667	8.286	1.108	18.488
2,3,6	50.507	11.058	5.093	1.155	16.003
TOTAL	50.825	10.924	5.750	1.140	16.797

551 agricultural holdings from 8 strata, with replacement, were chosen for the survey. In order to maintain a high response rate, if an enumerator was not able to trace a specific farmer, that farmer was replaced with another farmer within the same stratum so long as this person had his land registered with the IACS department. The aim of the survey was to interview the farmer on fertiliser use at parcel level and thus, due to the complexity of the survey, only holdings that had IACS site plans were interviewed. In cases where the holdings could not be replaced and no IACS site plans were available the interviewer still had to interview the farmer but these types of holdings were few and far between. For this survey, the unit observation was the parcel while the unit of enumeration was the holding. All the parcels on the holding were to be analysed but only the parcels with specific crops were asked specific questions on fertilisers. The other parcels with minor crops were considered as not being fertilised due to their limited importance both on the holding and also at national level.

Where a holding could not longer be replaced within a stratum, the weights were adjusted with the formula below.

$$W_{adj/h} = W_h \times \left(\frac{n_h}{n_h - r_h} \right)$$

where:

$W_{adj/h}$ is the adjusted weight of stratum h

W_h is the initial sample weight of stratum h

n_h is the number of holdings in the sampled stratum h

r_h is the number of non-response holdings within stratum h

Overall, 513 agricultural holdings were successfully surveyed, representing a response rate of 93.1 per cent.

The use of IACS site plans was beneficial to both the farmer and the interviewer. Through the use of the site plans, the farmer could pin point the use of fertilisers for each crop within each parcel, reducing the burden on the farmer and at the same time obtaining reliable data.

3.1.3 Selection of crops

The agriculture and fisheries unit undertook the survey on nitrogen balances for the first time and as a result had no prior experience on which crops to survey. With the help of officials from the Ministry for Resources and Rural Affairs, the selection of crops for the survey were based on three criteria - the intensity of fertiliser use, the area coverage of the selected crop and the number of holdings with that particular crop. The crops chosen were deemed to be statistically representative at national level as reporting was to be done at national level only. If the intensity of fertiliser use was high and the crop was excluded from the survey, this was due to the fact that the land coverage was either very small or because the number of farmers cultivating this crop were limited. In either case, a census on this particular would have to be undertaken, which would result in an overall larger sample and thus a greater financial burden.

Fodder crops and potatoes were surveyed, as these were the most commonly cultivated crops. Crops with a low fertiliser use, a low coverage area or crops cultivated by only a few agricultural holdings, such as plums, were excluded as the fertiliser use would be negligible. Certain types of crops were grouped in order to obtain the overall coverage of the utilised agricultural area of the holding although fertilisers on these particular crops were not asked for. A case in point is where, for example, a farmer simultaneously cultivated green beans and peas. These were grouped together under a code for other vegetables.

Table 9. Expected intensity of fertiliser use by crop

Crop	Crop code	Surveyed for fertiliser use
Set-aside	11	No
Forage	12	Yes
Potatoes	13	Yes
Onions	14	Yes
Carrots	15	Yes
Tomatoes	16	Yes
Vegetable marrows	17	Yes
Sugar melons	18	Yes
Watermelons	19	Yes
Other vegetables	20	No
Grapes	21	Yes
Citrus fruit	22	Yes
Peaches	23	Yes
Other stone fruit	24	No
Other permanent crops	25	No
Plants and Flowers	26	No
Tomatoes greenhouse	27	Yes
Greenhouse vegetable marrows	28	Yes
Greenhouse sugar melons	29	Yes
Greenhouse watermelons	30	Yes
Greenhouse other vegetables	31	No

3.2 TRAINING OF INTERVIEWERS

Personnel, from the Ministry for Resources and Rural Affairs, with a sound background in this field, were selected to act as enumerators and briefed extensively to carry out the survey on the selected farmers. A detailed briefing at the NSO premises was held in order to explain the questionnaire and the importance of the project.

Ten (10) interviewers were engaged for the collection of fertilisers. The survey period covered the crop year from September 2006 to August 2007. A briefing was held at the end of June 2007 to explain in detail the questionnaire and the method of data collection. Each interviewer was provided with a list of farmers and an instruction manual. Two sessions were held at the NSO premises, the first to explain the contents to be collected and the second session was a brainstorming session for interviewers to ask questions on particular problems.

3.3 DATA COLLECTION

Farmers were informed by mail and were eventually interviewed individually by the enumerators. Enumeration started in the second week of July 2007 and was concluded by the end of September 2007. Two stages were required to collect the data from the farmer. The first stage of data collection, also known as the *summary questionnaire*, was where the interviewer had to fill in information on all parcels within the agricultural holding. This questionnaire gave an overview on the agricultural area of the holding at parcel level. The data collected from the summary questionnaire was as follows:

- the area of a crop cultivated in that particular parcel;
- the type of crop cultivated;
- the number of times this area was utilised during the season;
- whether or not the crop was irrigated;
- whether or not the crop was fertilised;
- the sowing and harvest dates;
- whether or not the parcel received any natural fertiliser during the agricultural year.

Each site plan has a unique number and the enumerator was instructed to list all the details of all the crops grown within that particular parcel of land. This was known as the primary stage and this was the data that had to be compiled in the *summary questionnaire*. Parcels on holdings with no IACS maps were classified as 999999.

The second part of data collection referred to fertilised areas. The *summary* and *fertilised areas* questionnaires were linked to one another by a unique number. Any crops identified as being fertilised in the summary questionnaire were marked in the fertilised areas questionnaire where detailed information was asked on fertilisers. The *fertilised areas* questionnaire incorporated specific questions such as:

- Areas applied with fertilisers
- 1st application date
- Interval of application (weeks)
- Number of applications per interval
- Duration of application
- Brand name of the product used
- Grade N-P-K
- Whether the product is a slow release product or not
- Amount applied per application
- Method of application

The time to complete a duly filled questionnaire depended on the amount of parcels the holder worked, the type of crops sown within each parcel and the different types of fertiliser applied to each crop. Due to the complexity of the survey, the estimated time to collect the data within the *summary* and *the fertilised areas* questionnaire took approximately 90 minutes.

A software program for the nitrogen balances survey was developed by the IT section within the NSO. In order to obtain the total use of fertiliser on the holding the software had incorporated certain conversions in

order to obtain the number of applications over the agricultural year. The total number of applications multiplied by the amount applied per application resulted in the total amount applied of fertilisers. The mathematical formula in obtaining the number of applications was:

$$\frac{\text{Number of applications per interval} \times \text{duration of application (weeks)}}{\text{Interval of applications (weeks)}}$$

For example, if a farmer applied fertiliser to a specific crop for 12 weeks and this farmer applied the fertiliser twice weekly, then the interval of application would be 1, the number of applications per interval would be 2, and the duration of application would result as 12. Thus the total number of applications would be $2/1 \times 12 = 24$ applications

It was decided not to apply any calibration methods, as land areas from the Census of Agriculture are 8 years old and any changes in crop areas may not necessarily be reflected.

3.4 CONTROL OF THE DATA

The data was immediately vetted after interviewing. The first stage of vetting was undertaken by MRRA officials with experience on fertiliser data. The MRRA officials were to vet the questionnaires on the data received and to identify whether the data collected makes sense. The second stage of vetting was undertaken by NSO officials to check for inconsistencies on how the data was collected. As in previous surveys, interviewers were to report back to the NSO after the first two completed questionnaires in order to monitor the data collected by the interviewer. Any errors made by the interviewer were corrected at once in order to minimise systematic errors. Where either MRRA officials or NSO officials could not correct the data, the questionnaire was sent back to the interviewer identifying the mistakes in the questionnaire, who had to contact the farmer for verification of the data or correction of the data. It was during this stage where the software application was developed by the IT unit within the NSO. When all the questionnaires were received by the NSO, the data was then inputted.

For such a specific survey, specialized officials from the Ministry for Resources and Rural Affairs were engaged for data collection on fertilisers. NSO officials could not act as interviewers due to the lack of experience within the fertiliser domain. In this project, all MRRA officials worked for the NSO under oath and that all data collected from the holdings could not be used otherwise. On suspicion that interviewers were using the data elsewhere, this would lead to an immediate termination of the interviewer with the NSO. This point was stressed in order to safeguard the interests of the farmers and the data collected from them.

The second stage of analysis took place after data inputting where any errors through data inputting were checked and any outliers of the data were identified.

Once the second stage of data validation and analysis took place, all relevant tables were compiled.

A copy of the questionnaire is attached in the Annexe.

3.5 DIFFICULTIES ENCOUNTERED AND LIMITATIONS TO THE SURVEY

The data collection process is by means no easy task and certain difficulties could not be avoided. The first problem encountered was that the farmer did not keep records implying that it was rather a difficult task in obtaining accurate information. This also had its repercussions on the average time the interview spent at the holding. Where agricultural holdings kept records, the data was much easier to obtain, the data was more reliable and the average time spent at interviewing a farmer declined.

Another problem encountered was that not all farmers are registered with IACS. This problem was even more profound when interviewing farmers in strata where all agricultural holdings were exhaustively

surveyed. As the survey was undertaken at parcel level it was rather complicated for the interviewer to obtain accurate information at parcel level on those holdings not registered with IACS.

In order to increase the accuracy and reliability of the data, ideally, the data should be collected by means of a panel survey although the cost of the survey would increase. As the survey was undertaken after the reference year elapsed it is more difficult to obtain accurate data on a specific parcel of land on a certain crop after such a lengthy period.

As the survey is rather complex and time consuming, the average time spent at a farmer is long and thus the farmer is constantly frustrated. This may lead to a decrease in the overall reliability of the data.

The main problem being faced by Malta was not the complexity of the survey itself but the amount of surveys being undertaken by the NSO and other institutions. Being a small country, it is very difficult to extract a reliable sample on any type of statistics if the large holdings, irrespective if it is in the agricultural domain or any other domain outside of agriculture, are not exhaustively surveyed. Due to the limited amount of these holdings, these holdings are always included in the sample. These farmers are also contacted to take part in the data collection process of other domains, such as business, labour force and other domains outside of agriculture. Due to the complexity of the survey this can result in farmers refusing to take part in other surveys, which is a problem faced by the Agriculture and Fisheries Unit when a large farmer does not want to take part in the interview. Fortunately, only a handful of farmers refused to co-operate and very few came from the large strata as refusal of these farmers could lead to an overall distortion in the results.

Administrative constraints are a major constraint being faced by many institutions nowadays. While budgetary constraints limit the actual sample size, human resource limitations are a major problem when conducting certain technical surveys. These surveys required skilled human resources, which in many cases, national statistical institutions do not have.

For a greater degree of accuracy and reliability, an up-to-date agricultural register is essential. The agricultural register, although maintained and updated, may still have its deficiencies. With this in mind, the final grossed up results may not be as accurate as they should be. Malta's next agricultural census will be held in 2010 and hence 8 years have elapsed since the last agricultural census took place. The further you move away from census data, the overall accuracy of the results tend to decline.

The gross nitrogen balance for Malta was calculated using a farm-gate model, using arable and horticulture farms as the basis for the calculation. The decision to limit the scope of the exercise to the farms rather than taking a wider consideration of all nitrogen inputs and outputs at national level (including, for example, imports of nitrogen through grains, and exports through processed products) was based on the fact that the main objective of this exercise was to quantify the GNB as an indicator of water pollution originating mainly from agricultural sources. The unavailability and unreliability of data on imports and exports would also have hindered the exercise.

This means that the scope of the task was limited to a calculation of gross nitrogen balance on a national scale but derived on the basis of the inputs and outputs of crop farms. This limitation to crop farms only rather than including animal production units as well is justified in view of the fact that in Malta, integrated production is not common and crop farms are in a sense a closed system whereby animal waste derived from animal production units is received and from which plant parts containing nitrogen are exported. Prior to the survey it was known that all manure, with the exception of pig slurry, is used for agricultural purposes. As a result it was not necessary to estimate the total quantity of manure produced on livestock farms as the estimated manure from livestock farms is very similar to the estimate of manure spread on agricultural crops as obtained from the survey. This was verified by officials at the research institute who specialise in the livestock industry.

The changes in stocks have a minimal effect on the overall balance and this is due to the fact that from one year to another the livestock populations are rather stable. National imports and exports were not taken into account as the importation of animals is considered negligible. No exports of animals were recorded.

These considerations do not in themselves limit the validity of the calculations, but rather define a scope of the calculations that should be adhered to in future exercises of the same type aimed at evaluating changes in the GNB.

The methodology used for calculating the indicator does not take into account certain variables for which no data exists at either regional or national scale. Therefore, it was not possible to carry out a quantitative assessment, such as the nitrogen fixation by legumes. In order to calculate the nitrogen fixation by legumes, a certain amount of basic information is needed, which depends on the type of formula and model used. The types of formula and model to use are generally identified after scientific study has been carried over a period of time. The basic information which is generally used is the N content of the shoots, roots and crop litter of each type of legumes. The complexity of the information required could not be collected within the survey undertaken.

Also atmospheric deposition was not taken into consideration as the calculations required are very complex. It is a known fact that in many EU and non-EU countries this data is collected over a period of time since these have to be computed spatially and temporally. Furthermore, the field elevation has also to be known to be able to calculate the wet and dry deposition. Wet deposition is referred to the precipitation, whereas the dry deposition is the deposition made in normal atmospheric condition (no precipitation). To be able to calculate the wet and dry deposition a continuous monitoring exercise is need together with specialised apparatus which is able to take such measures.

Through the survey it was also not feasible to estimate the input of nitrogen via nitrate-rich irrigation water. Presently, in Malta the usage of water for irrigation for agricultural crops is not measured and hence actual calculations cannot be made. On the other hand, to determine the amount of nitrogen being applied from irrigation water without the input of any fertiliser, one has also take in consideration the usage of water for agricultural crops together with the nitrate levels in irrigation water. The nitrates level in irrigation water has be taken spatially and temporally. In order to collect this data another project is required as it requires a sample on its own to collect data on the amount of water used in one week per each type of crop and the nitrate level in irrigation water. It would be impossible to obtain so much complex information, both in the use of fertilisers and also on the use of irrigation, in one questionnaire, even more so when the majority of the farmers extract water without it being metered.

Finally, the escape of nitrogen to the atmosphere and losses of nitrogen by leaching, were not taken into account as there are no scientific studies that have tried to determine these values experimentally for conditions that are specific to Malta.

The calculations on outputs are mainly based on production statistics at national level. This type of limitation could not be overcome by questioning the farmer directly on crop yields because it would have been impossible for the farmer to remember the total production over the previous agricultural year. Another limitation in this survey is also associated with the nitrogen exported from the farm through the cultivation of secondary crops that are not marketed, ornamental and peripheral plants within the agricultural parcel, and the removal of crop residues.

3.6 THE COST OF THE SURVEY

Table 10. Expenses incurred in survey implementation

	Budgeted expenditure	Actual expenditure
	€	€
Total	32,739.71	23,273.60
Staff Costs	27,019.86	21,751.03
<i>Permanent Staff</i>	<i>15,703.13</i>	<i>11,450.70</i>
<i>Temporary Staff</i>	<i>11,316.73</i>	<i>10,300.33</i>
Travel/Subsistence Costs	1,328.00	-
Sub-contracting	2,250.00	-
Other Direct Costs	-	-
Eligible Indirect Costs (7%)	2,141.85	1,522.57

4 CALCULATION OF THE GROSS NUTRIENT BALANCE

Two sources of data collection were utilised to calculate the gross nutrient balance. In order to calculate the input of nitrogen, farmers were interviewed directly on the application of mineral fertilisers and manure within each parcel. For each mineral fertiliser application, the interviewer collected the N-P-K percentage of each fertiliser. It was imperative that the interviewer collected the N-P-K percentage rather than the N-P-K ratio as a fertiliser containing a percentage N-P-K of 20-20-20 has a similar ratio as a fertiliser containing a percentage N-P-K of 10-10-10. The results of the total amount of fertiliser and manure applied at crop level are shown in the Table 11.

Table 11. Amount (kg) of mineral fertiliser and manure applied excluding slurry

Crop	Crop Area (ha)	Total amount of mineral fertiliser applied (kg)	Total manure excluding slurry (kg)
Potatoes	1,109.4	560,349.6	39,430,332.7
Carrots	16.2	2,678.8	179,187.5
Onions	322.3	134,841.2	7,377,342.8
Sugar Melons	162.2	123,950.4	6,981,373.4
Tomatoes	264.4	390,479.8	8,655,977.0
Vegetable Marrows	149.0	178,816.6	5,195,777.7
Watermelons	95.2	109,322.9	5,634,156.7
Forage	4,964.3	1,573,793.7	67,402,211.9
Vines	723.6	291,216.8	4,080,700.4
Citrus Fruit	84.0	51,929.0	1,961,399.1
Peaches	218.2	84,381.0	1,261,486.0
Set-aside	924.2	268.9	1,404,562.6
Other Vegetables	1,096.3	-	-
Other Permanent Crops	381.1	-	-
Plants & Flowers	52.1	-	-
Total	10,562.5	3,502,028.8	149,564,507.9

From the table above it can be revealed that information on fertiliser input on other vegetables, other permanent crops and plants and flowers were not collected. It was impossible to obtain fertiliser use on all crops and it was discussed with officials within the Ministry that fertiliser use and manure spread on these crops were considered negligible.

In order to calculate the gross nutrient balance, it was important to take into consideration the slurry produced by pigs. In contrast to other animal manure, only a fraction of pig slurry is applied as fertiliser. The reason being is that pig slurry is collected in cesspits from every pig farm. This is collected by suction into a bowser and is discharged into sewers through specific discharge points. The slurry then follows the normal drainage sewage lines.

The utilisation of pig manure was not estimated directly from the survey, therefore it was necessary to calculate the national production of pig manure and the amount of nitrogen produced as shown in the following table. The average number of pigs by type of pig was derived from the annual pig surveys undertaken by the Agriculture and Fisheries Unit every December for 2006 and 2007 and these figures were

multiplied by the average daily manure produced by each type of pig that was provided by the research institute.

Table 12. Annual pig manure (kg)

Type of pig	Average number of pigs	Average manure per day (kg)	Annual pig manure (kg)
Piglets	17,926	1.2	7,851,369
Young Pigs	21,027	2.4	18,419,652
Fattening Pigs	28,342	4.2	43,447,520
Breeding Stock	7,998	10.2	29,774,693
Total	75,292		99,493,233

Information from the *Agricultural Waste Management Plan for the Maltese Islands – Draft Final Report 2005* was taken. It was estimated that the total amount of pig slurry through the report was estimated at 4.2 times the estimated amount of pig manure produced. Thus the estimated pig slurry produced was estimated at 418 thousand tonnes. Through this report it was identified that the Nitrogen content in pig slurry was estimated at 1809 mg/l or 0.18 per cent of the total pig slurry. This estimate was derived through a sample of pig slurry produced directly on number of pig farms. It was confirmed by experts in animal husbandry that the percentage of nitrogen in pig slurry was low due to the fact that Maltese pig slurry is heavily diluted. Thus, the total nitrogen content derived from pig slurry amounted to approximately 760 tonnes.

From the total fertiliser application, the percentage of nitrogen content was calculated both for mineral fertilisers and also for manure as shown in Table 13. The total nitrogen input can be calculated by summing the N content of mineral fertilisers, the N content within manure and the N content contained within the pig slurry not applied as fertiliser (Table 14).

Table 13. Weight (kg) of N applied

Crop	Crop Area (ha)	N content from mineral fertiliser (kg)	N content from Manure (kg)	Total N content (kg)
Potatoes	1,109.4	89,307.5	263,733.3	353,040.8
Carrots	16.2	400.2	1,198.5	1,598.8
Onions	322.3	26,493.9	49,344.0	75,837.9
Sugar Melons	162.2	20,587.4	46,695.5	67,282.9
Tomatoes	264.4	61,446.6	57,896.3	119,342.9
Vegetable Marrows	149.0	22,132.9	34,752.4	56,885.4
Watermelons	95.2	19,085.2	37,684.6	56,769.8
Forage	4,964.3	331,403.7	450,825.7	782,229.4
Vines	723.6	44,754.5	27,294.1	72,048.6
Citrus Fruit	84.0	7,819.8	13,119.0	20,938.8
Peaches	218.2	13,454.2	8,437.6	21,891.7
Set-aside	924.2	56.5	9,394.5	9,451.0
Other Areas ¹	1529.5	-	-	-
Total	10,562.5	636,942.5	1,000,375.5	1,637,318.0

¹ Other areas include other vegetables, other permanent crops and plants and flowers

Table 14. Total nitrogen input (kg)

N content	Kg
Mineral fertiliser used on agricultural holdings	636,942.5
Animal manure used on agricultural holdings	1,000,375.5
Pig slurry	755,929.7
Total N content	2,393,247.7

In order to calculate the gross nutrient balance, the percentage of N had to be calculated from the crop production. Data on production figures were taken from crop product statistics where the average production for the crop years 2006 and 2007 were used. Data on land areas was collected from the survey and these referred to the crop year September 2006-August 2007 while crop production figures referred to the calendar years 2006, 2007. The crop yield can be seen in the table below.

Table 15. Yield (t/ha)

Crop	Crop Area (ha)	Average Production 2006 - 2007 (t)	Yield (t/ha)
Potatoes	1,109.4	15,390	13.87
Carrots	16.2	1,364	84.08
Onions	322.3	8,096	25.12
Sugar Melons	162.2	4,530	27.93
Tomatoes	264.4	15,651	59.20
Vegetable Marrows	149.0	3,692	24.78
Watermelons	95.2	4,868	51.12
Forage	4,964.3	29,542	5.95
Vines	723.6	4,884	6.75
Citrus Fruit	84.0	1,804	21.48
Peaches	218.2	1,148	5.26
Set-aside	924.2	0	0
Other Areas ¹	1529.5	-	-
Total	10,562.5	-	-

¹ Other areas include other vegetables, other permanent crops and plants and flowers

As no scientific experiment on the calculation of nitrogen required per hectare was undertaken, in order to calculate the amount of nitrogen required in Kg/ha, officials from the Ministry for Resources and Rural Affairs submitted a list of crops from *Il Nuovo Manuale di Concimazione*, 2nd edition Mariono Perelli and Ferdinando Pimpini on the N required in Kg/ha for specific yields. This yield was compared to the yield obtained from the survey and an N adjusted in Kg/ha was calculated. This can be seen in the table below.

The calculation of the adjusted N in kg/ha pertaining to yields from Maltese agriculture was as follows:

$$\left[\left[\frac{\text{Actual yield}}{(\text{Yield manual} \times 2)} \right] + 0.5 \right] \times \text{N req Kg/ha}$$

Table 16. Calculation of adjusted N (kg/ha)

Crop	Crop Area (ha)	Yield (t/ha)	² Estimated yield (t/ha)	² N required (kg/ha)	N adjusted (kg/ha)
Potatoes	1,109.4	13.87	30	150	110
Carrots	16.2	84.08	30	90	171
Onions	322.3	25.12	30	120	110
Sugar Melons	162.2	27.93	40	150	127
Tomatoes	264.4	59.20	50	130	142
Vegetable Marrows	149.0	24.78	26	130	127
Watermelons	95.2	51.12	50	160	162
Forage	4,964.3	5.95	5	150	164
Vines	723.6	6.75	15	110	80
Citrus Fruit	84.0	21.48	25	200	186
Peaches	218.2	5.26	20	125	79
Set-aside	924.2	0	0	0	0
Other Areas ¹	1529.5	-	-	-	-
Total	10,562.5	-	-	-	-

¹ Other areas include other vegetables, other permanent crops and plants and flowers

² The estimated yield and required N uptake prior to adjustment were taken from the *Il Nuovo Manuale di Concimazione*, 2nd edition Mariono Perelli and Ferdinando Pimpini

To estimate the output of nitrogen from the crops surveyed, the N adjusted in Kg/ha was multiplied by the crop area that resulted from the survey. This would give an overall N uptake resulting from the area under a specific crop.

Table 17. Estimation of N (kg) from crop production

Crop	Crop Area (ha)	N adjusted (kg/ha)	Total N uptake (kg)
Potatoes	1,109.4	110	121,678.4
Carrots	16.2	171	2,775.9
Onions	322.3	110	35,532.1
Sugar Melons	162.2	127	20,662.3
Tomatoes	264.4	142	37,532.6
Vegetable Marrows	149.0	127	18,916.1
Watermelons	95.2	162	15,407.5
Forage	4,964.3	164	815,447.2
Vines	723.6	80	57,702.7
Citrus Fruit	84.0	186	15,613.8
Peaches	218.2	79	17,226.6
Set-aside	924.2	0	-
Other Areas ¹	1529.5	-	-
Total	10,562.5	-	1,158,495.3

¹ Other areas include other vegetables, other permanent crops and plants and flowers

From the table below, the gross nutrient balance for the total land area was calculated by deducting the total N output from the total N input.

Table 18. Calculation of Gross Nutrient Balance (kg/ha)

Crop	Kg
Mineral fertiliser	636,942.5
Manure excluding pig slurry	1,000,375.5
Pig slurry	755,929.7
Total N input	2,393,247.7
Total N uptake	1,158,495.3
GNB	1,234,752.4
Crop Area	10,562.5
GNB (kg/ha)	116.9

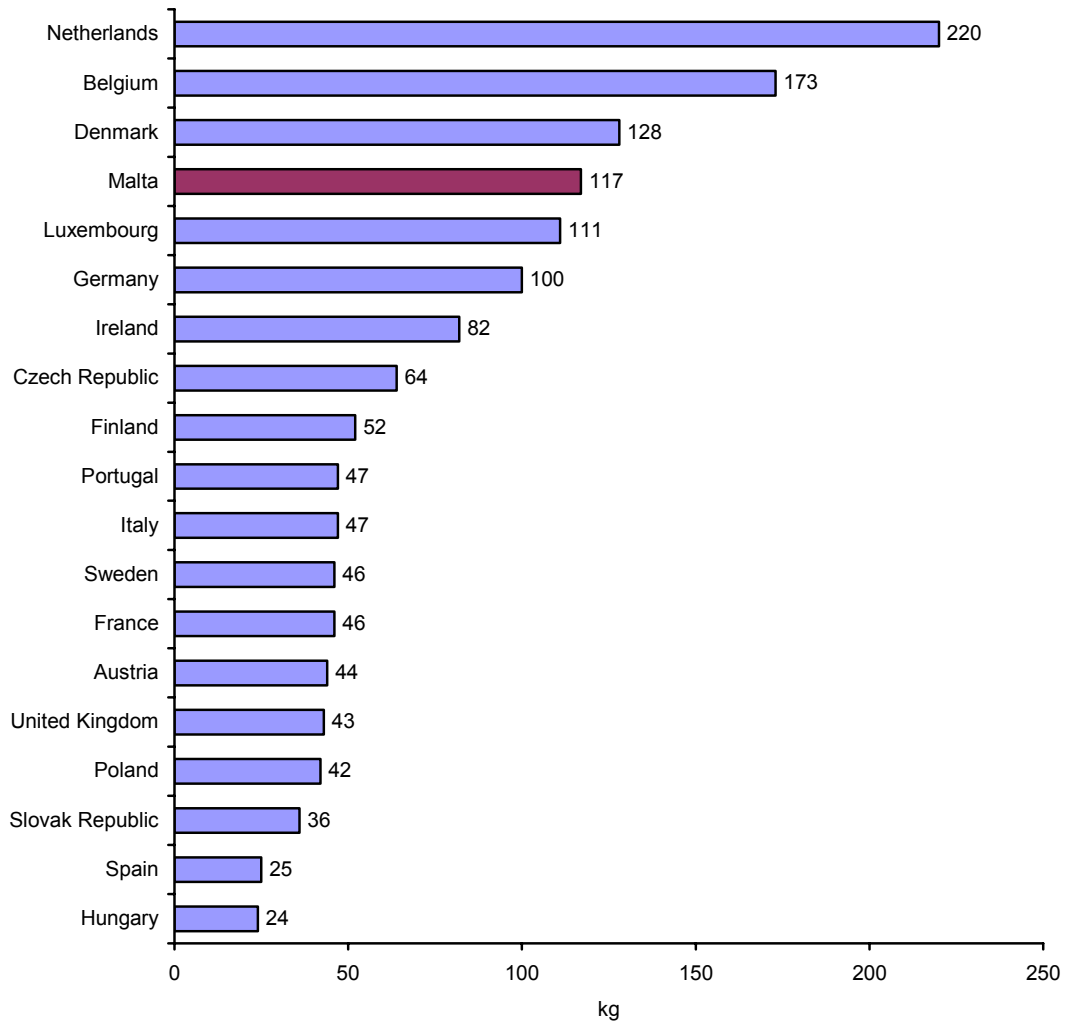
A cross comparison of the result of the Gross Nitrogen Balance with other Member states can be seen in the table below. The data for the Member States was taken from the OECD.

Table 19. The Gross Nutrient Balance per Member State

Country	Year	GNB in kg/ha
Austria	2004	44
Belgium	2004	173
Czech Republic	2004	64
Denmark	2004	128
Finland	2004	52
France	2002	46
Germany	2004	100
Greece	2003	12
Hungary	2004	24
Ireland	2004	82
Italy	2002	47
Luxembourg	2004	111
Malta	2007	117
Netherlands	2004	220
Poland	2004	42
Portugal	2004	47
Slovak Republic	2004	36
Spain	2002	25
Sweden	2004	46
United Kingdom	2004	43
Median of GNB (kg/ha)		47

At the time of the compilation of this report, no data was available for Slovenia, Estonia, Latvia, Lithuania, Cyprus, Bulgaria and Romania. The data compiled in Table 19 reveals the most recent data at which one may be able to compare the Gross Nutrient Balance for Malta as obtained in the survey with that of other Member States.

Chart 4. Gross nutrient balance (kg N/ha)



In descending order the graph clearly shows that there is a wide disparity of the gross nitrogen balances among Member States. In fact the median of the GNB (kg/ha) as shown in Table 19 amounts to 47 kg/N per hectare, with the highest GNB in the Netherlands with 220 kg/N per hectare to the lowest in Greece with a GNB of 12 kg/N per hectare. Malta, at 117 kg/N per hectare, is approximately two and a half times as much as the median of the gross nitrogen balances within the Member States.

5 RECOMMENDATIONS

It is recommended that for future surveys of the same type the amount of nitrogen in irrigation water is quantified, since we acknowledge that this is a significant input into the agricultural system. This could be done by using the results of a survey on irrigation to calculate water consumption by farmers and integrating results with data on the chemical quality of irrigation water with respect to its nitrate content.

In order to undertake such complex surveys a cost benefit analysis must be taken into consideration. In undertaking this survey the farmer was asked on the fertilisers used on the agricultural holding over the previous twelve months. Although the overall level of the data collected can be considered as satisfactory, the collection of certain data over a long period of time is often quite difficult to obtain. In order to improve the overall level of data collection it would be advisable to undertake panel surveys where farmers are interviewed over a period of 4 weeks on his most recent applications. Although this may be a more costly procedure to implement, the quality of the data obtained will be of higher standard.

6 PUBLICATION AND DISSEMINATION

A news release disseminating the final results of the Nutrient Balance survey in Malta will be published in the third quarter of 2008. These results, broken down in detail by subject matter will also be available on the National Statistics Office website in PDF-format.

The tables in the release will include information on the structure area surveyed, the total fertilised area, application rates, and will also include information on the Gross Nitrogen Balance. The data will also be compared to the GNB's of other Member States.

ANNEXE

KUNFIDENZJALI WARA LI JIMTELA
CONFIDENTIAL AFTER FILLED IN

Ibdeġ 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	

Stharriġ dwar l-użu tal-Fertilizzanti
1 ta' Settembru 2006 – 31 ta' Awissu 2007

Kwestjonarju - Użu tar-raba'

Survey on the use of Fertiliser
1st September 2006 – 31st August 2007

Questionnaire – Land use

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 penaltajiet 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

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Nru Karta ta' l-Identità
Id Card No

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Nru Tel
Tel No.

--	--	--	--	--	--	--	--	--	--

Nru Mobile
Mobile No.

Agriculture and Fisheries Unit
Lascaris, Valletta CMR 02, Malta
Tel: +356 25 997 529 Fax: +356 25 997 522
agric.nso@gov.mt, <http://www.nso.gov.mt>

Summary

Lc Urn

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Page

of

Row Number	Parcel Number	Area under parcel (ha)	Manure Code ^B	Cycle Number	Crop Code ^A	Area under crop (ha)	Irrigated Yes=1 No=2	Fertilised Yes=1 No=2	Sown Date mm/yy	Harvest Date mm/yy
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[illegible]

^A Crop Code

- | | |
|----------------------|--------------------------|
| 99 Manure | 18 Sugar Melons |
| | 19 Water Melons |
| 11 Set-aside | 20 Other Vegetables |
| 12 Forage | |
| 13 Potatoes | 21 Vines |
| 14 Onions | 22 Citrus Fruit |
| 15 Carrots | 23 Peaches |
| 16 Tomatoes | 24 Other Stone Fruit |
| 17 Vegetable Marrows | 25 Other permanent crops |

^B Manure Code

- 1 Yes Cattle
2 Yes Poultry
3 Yes Other
4 No

KUNFIDENZJALI WARA LI JIMTELA
CONFIDENTIAL AFTER FILLED IN

Ibdeġ 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	

Stharriġ dwar l-użu tal-Fertilizzanti
1 ta' Settembru 2006 – 31 ta' Awissu 2007

Kwestjonarju - Raba' bil-Fertilizzanti

Survey on the use of Fertiliser
1st September 2006 – 31st August 2007

Questionnaire – Fertilised Areas

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

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Refusal or false declarations may incur penalties.

Persuna ta' Riferenza
Reference Person

Firma
Signature

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Nru Karta ta' l-Identità
Id Card No

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Nru Tel
Tel No.

--	--	--	--	--	--	--	--	--

Nru Mobile
Mobile No.

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Row Number	Parcel Number		Cycle Number	Crop Code ^A	Area under crop (ha)	Area Applied with Fertiliser (ha)	1 st Application Date mm/yy	Interval of application (weeks)	No of applications per interval	Duration of application (weeks)	Product					Amount Applied per application Kgs/Lts	Method of application ^c
											Brand Name	Grade			Slow ^B release		
												N	P	K			

^ACrop Code

99 Manure

11 Set-aside

12 Forage

13 Potatoes

14 Onions

15 Carrots

16 Tomatoes

17 Vegetable Marrows

18 Sugar Melons

19 Water Melons

20 Other Vegetables

21 Vines

22 Citrus Fruit

23 Peaches

24 Other Stone Fruit

25 Other permanent crops

26 Plants & Flowers

27 Tomatoes - GH

28 Vegetable Marrows - GH

29 Sugar Melons - GH

30 Water Melons - GH

31 Other vegetables - GH

^BSlow release

1 Yes

2 No

3 Don't know

^CMethod of Application

1 Knap Sack / Foliar

2 Broadcast

3 Incorporated

4 Fertigation

5 Other

