Executive Summary:

The aim of this project is to provide a methodological framework that will serve as the foundation for the introduction of EU and national policies aimed at achieving sustainable use of pesticides in European agriculture. This is accomplished through, first, a detailed assessment of the external costs of agricultural pesticide use on producers, consumers, and the environment, and second, the design of a socially optimal tax and levy scheme aimed at the reduction of pesticide use to its socially optimal level, and the study of probable effects.

The project has successfully fulfilled its aims, by combining traditional and well-established theoretical methodologies with the most recent advancements in economic theory, building also upon the biological and technical scientific work developed over the last years on pesticide use. The validity of the employed theoretical models and policy tools was verified in case studies in several EU countries (Bulgaria, Cyprus, France, Greece, Netherlands (included in all case studies, however no in the Annex, to derive comparable results), Portugal, Sweden, UK), to account for the diversity in pesticide use among producers in different geographical locations, farming practices and farmer attitudes. At the same time, the effects of the developed scheme and alternative policy tools on the optimal pesticide use, as well as on economic sustainability and social welfare were assessed. Ultimately, policy recommendations, relative data, literature and tools are delivered that can be further used by policy makers, researchers, and stakeholders.

More specifically, the results of the analysis regarding the evaluation of the effects of pesticides on farmers' productivity indicated that agriculture benefited by the use of pesticides. Over the past decades, increases in pesticides use enhanced farmers' productivity and resulted in production growth. Nevertheless, production growth caused by pesticides was decelerated due to significant impairments in farmers' health, mainly due to inappropriate pesticide use and lack of education. The results of the analysis regarding the environmental impact of pesticides on the environment suggest that pesticide environmental toxicity differs significantly among pesticides and environmental toxicity does not necessarily correlate with human health toxicity of pesticides. Furthermore, the carrying capacity of the aquatic environment significantly determines the amount of traceable pesticide residues. The external cost of pesticides on consumers/residents was determined through choice experiments and assessment of their willingness-to-pay for products with various levels of pesticide residues. Consumers' willingness-to-pay for products perceived without pesticides (organic) compared to regular and integrated pest management indicate that consumers' premium for pesticide reduction is not independent from the product's sensory attributes. Moreover, the results show that income is not significant in explaining the premium for organic products, which implies that the demand for organic products is likely to grow significantly within the EU in the coming years.

The analysis of the effectiveness of different economic instruments, such as taxes and levies, in encouraging farmers to decrease their intensity of pesticide applications highlighted the inherent dilemma in pesticide taxation concerning the use of pesticides which is considered essential for some crops or regions, and tax rates would have to be very high to modulate pesticide use. This could result in a major reduction in farm income as depicted through the pesticide tax scenarios presented in this study. The results of the study indicate that high taxes or levies are required in order to achieve considerable pesticide reduction targets. In addition, socially optimal tax rates vary widely among countries (e.g. 25 per cent for the UK and 76 per cent for the Netherlands). Furthermore, taxes that differen

Project Context and Objectives:

Summary description of project context and objectives

The project's two main scientific objectives are (i) to develop a consolidated methodological framework comprised of detailed qualitative and quantitative analytical tools, in order to identify external costs of pesticide use, and (ii) to propose, test and validate a system of taxes and levies and studying the feasibility of such alternative regulatory systems.

By addressing these issues, the project fulfilled the following specific objectives in a measurable, scientific way:

- To assess the impacts of pesticide use on yield, efficiency and productivity (WP1).
- To cast the impact of pesticide use on farm operators and residents (WP2).
- To estimate the environmental effects induced by pesticide use (WP3).
- To assess the impact of pesticide use on consumers (WP4).
- To estimate the socially optimal level of pesticide use at the farm level (WP4).
- To design and study an effective tax and levy scheme that reduces the use of pesticides to a socially optimal level from the point of view of a policy maker (WP5-6).
- To assess producers' willingness to adopt low pesticide use production methods (WP7).
- To assess the policy schemes for reducing the indirect cost of pesticide use (WP8).

WP1: External costs on agricultural productivity

The aim of this work package is to determine the impacts of pesticide use on yield, efficiency and productivity. The first objective met in this work package is the construction of a complete and thoroughly revised database, providing information on various aspects and characteristics of pesticides and their appropriate use. This database has been created with the collaboration of other partners specializing in different directions and is publicly available through the web-based tool of the projects Internet site.

The main goal achieved in WP1 is the development of the theoretical framework measuring productivity, efficiency and shadow pricing in order to produce agricultural policy implications concerning producers, policy makers and researchers today. Two models were constructed: The first model focuses on the stochastic element of the production process that traditional methods usually neglect and led to mis-measurement of productivity and efficiency indicators. Agricultural production is a representative stochastic procedure, which if considered non-stochastic, it could end up in inefficiency and loss of resources. The development of a dual farm model for productivity measurement completes the theoretical framework, taking into account the unique nature of farm production.

WP2: External costs on farmers' health

The aim of this work package is to investigate the effects of pesticide use on farm operators' health, as well as productivity differences among farmers. The first objective of this work package is the addition to the literature database of strands on the effects of pesticides on farmers' human capital and on the impacts of health effects on farmer's productivity. The findings came up from the literature reviews have been combined with the findings from the corresponding Tasks of WP1, providing important insights about the mechanism that underlines the relation among pesticides use, farmers' health status and farms' productivity performance. At the same time, the partners of WP2 and WP1 have successfully cooperated and coordinated the collection of all relevant literature on the measurement of Total Factor Productivity in agriculture. The collected literature has been deeply investigated and a detailed report was developed summarizing the applied methods that analyse the economic role of pesticides in farm production. The second objective of the WP was the development of a questionnaire and the undertaking of a small-scale survey in selective regions in Greece, Bulgaria and the Netherlands.

The main goal achieved in WP2 is the development of an integrated theoretical framework to analyse the impact of pesticides use on farms' productivity growth taking into account the productivity effects due to the deterioration of farmers' health. Specifically, farmers' productivity growth has been decomposed into several parts, capturing both the positive and negative health effects of pesticides use on farms' productivity levels. The theoretical model developed during this period was empirically applied to the three case countries, i.e., Greece, Bulgaria, and Netherlands. The quantitative results from the econometric application provided a complete picture for the economic impact of pesticides use on both farmers' health and productivity. Analytical tables and graphs for all three case countries were constructed and a detailed report analyzing the methods used and the empirical findings was developed. Finally, based on the empirical results and findings, a set of policy recommendations was developed at the end of the project's period proposing policy measures for increasing the productivity gains from pesticides use in farm production and reducing their associated health risks. The two WPs (WP1 and WP2) are highly interrelated, thus work and models have been combined to assess the final outcome.

WP3: External costs on the environment

The aim of this work package is to investigate the linkage between changes in agricultural production and environmental damage on surface waters, using a pesticide indicator of environmental damage. In addition, the work package will address how costs of adopting beneficial management practices, resulting in reduced deterioration of surface water quality, can be calculated using mathematical modelling. The first objective of this work package is to evaluate the use of indicators for pesticides in surface water, as proxies for environmental damages associated with pesticides use. The second objective is the evaluation of the risk effect for determining indicator targets associated with three types of risk: for events, normal conditions and concentrations, that arise with the use of pesticides in agricultural production. The third objective is the estimation of the field level production costs of alternative beneficial management practices to achieve indicator targets for levels of chemical substances associated with agricultural practices found in surface waters. The fourth objective is the scaling up of estimated costs for field level beneficial management practices to a catchments (regional) level and the final objective is the synthesis of tasks into catchments scenarios for policy and program analysis of agricultural pesticide use based on the costs of beneficial management practices and targets for environmental damage indicators for surface water.

WP4: External costs on consumers

The main objective of this work package is to examine the impact of pesticides reduction from a consumer point of view. The work package integrates a literature survey, which enables us to undertake experimental markets according to our topics. The four main questions of this WP were the following:

- Do the consumers really ask for a pesticide reduction in fruits and vegetables and how much do they agree to pay for that?
- If there is a request on pesticide reduction from the consumers, what is the best way to signal the reduction? (via a public or a private cue? via an involvement from the producers or the retailers? via an association with other quality cues not directly bond with the environment? etc.)
- Do the consumers valuate organic products?
- What is the efficient way to take into account the consumer WTP in order to improve the European regulation of pesticides for fresh and processed agricultural products?

The main purpose of our experiments is to evaluate the relative influence of the reduction of pesticide in the WTP, compared to the influence of other attributes like taste, appearance, etc. In this task, we particularly work on an experimental market protocol, which enables us to measure how the quality cues carry information on safety issues and defence of the environment. The experimental design permits testing of a number of hypotheses concerning the performance of experimental markets as a means of revealing consumer WTP (Willingness to pay) and WTA (Willingness to accept). The strategy analysis is chosen to reflect the nature of information collected in experimental markets and the validation of the hypotheses defined.

WP5: Tax and Levy Schemes

The aim of this work package is to assess the determine the socially optimal pesticide use, while taking into consideration the economic sustainability and biodiversity loss aspects of the socially optimal pesticide use level. The first objective of this work package is to assess the existing theoretical and empirical literature on modeling economic sustainability, valuing biodiversity, and defining pesticides tax policy in the context of economic growth and externalities. The second objective is to evaluate the impacts of the tax and levy scheme on farm-level decision making to gauge the micro-foundations of the alternative macro-level solutions. The third objective is to implement an empirical investigation of pesticide tax and levy schemes to assess the impacts on agriculture and the environment.

WP6: Optimal Tax and Levy Policy

The aim of this work package is to develop agricultural support policies and optimum tax and levy schemes on pesticide use in farm production. The first objective of this work package is a Report on Literature Review and a Detailed Database on Aggregate Agricultural Control Inputs. The second objective is a Dynamic Macroeconomic Model of Effective Pesticide Use and Effective Tax and Levy System. The third objective is a Dynamic Macroeconomic Model on the Effects of Agricultural Supports on the Effective Pesticide Use". The fourth objective is an Empirical Investigation of Policy Effects on Optimal Pesticide Use with Emphasis on Constructing an Effective Tax and Levy Scheme.

WP7: Incentives for pesticide substitution

The aim of this work package is to assess the feasibility and potential benefits of producers adopting low-pesticide input systems through evaluating a range of socio-economic factors affecting producers' willingness to adopt low pesticide input production methods in arable production and in horticulture and permanent crops. The specific objectives are:

1. Develop an interdisciplinary framework identifying economic and social factors that influence the adoption of organic farming and other low pesticide input systems among the sectors that most likely use pesticides;
2. Assess the relative profitability of organic and reduced pesticide system management compared to traditional methods and the impact of shifting to a different, low pesticide input production function for different farm types;
3. Develop a range of different scenario models for varying levels of relative profitability for low pesticide input production. These models will be tested to different farm types;
4. Identify the producers' response to profitability scenarios through discussion groups with producers of different types in the UK, Bulgaria and the Netherlands.

WP8: Implementation policy recommendations

The aim of this work package is to draw from the different points of analysis from the previous work packages and to construct a wider framework. Hence, in this work package the main aim is to summarize the results and to synthesize them under a broader perspective so as to generate a solid policy framework that includes agricultural policy measures, consumer protection measures as well as environmental policy measures.

Project Results:

Description of the main S&T results/foregrounds

WP1: External costs on agricultural productivity

WP1 analyses pesticide productivity, efficiency, and shadow pricing for stochastic agricultural production technologies. The main goal of this work package is to examine the determinant characteristics of agricultural productivity under a stochastic setting and to provide worthy agricultural policy recommendations based on the latest results of theoretical and empirical developments in this area. This is achieved with the development of the theoretical framework measuring productivity, efficiency and shadow pricing in order to produce agricultural policy implications concerning producers, policy makers and researchers today. Two models were constructed: The first model focuses on the stochastic element of the production process that traditional methods usually neglect and led to mis-measurement of productivity and efficiency indicators. Agricultural production is a representative stochastic procedure, which if considered non-stochastic, it could end up in inefficiency and loss of resources. The development of a dual farm model for productivity measurement completes the theoretical framework, taking into account the unique nature of farm production.

The theoretical models developed in this work package examine the stochastic nature of agricultural production and the level of mis-measurement of efficiency, productivity, and shadow prices, which occurs when considering the production process to be non-stochastic. These models show that, if the effect of stochastic elements is not adequately distinguished and is considered to be part of the actual efficiency and productivity measures, the presence of heterogeneity across decision making units may lead to inaccurate measurement of efficiency and productivity. Such heterogeneity may arise from many different sources, as for example, stochastic factors that are both beyond the decision maker's control and not known at the time that basic production decisions are made.

The stochastic element in the agricultural production process is one of the most typical of such examples. In this work package we examine how the uncertainty on pest infestation affects producers' decisions and how this effect should be measured adequately. Individuals facing stochastic, but favourable, production conditions may appear to be either more efficient or more productive than individuals facing unfavourable stochastic production conditions, even if both make the exact same production decisions. This element has not been taken into account by many contemporary methods, considering the effect of uncertainty of pest infestation as inefficient use of pesticide inputs.

A systematic approach is developed so as to incorporate technically based heterogeneity into productivity and efficiency analysis, with a special emphasis on DEA models. We first develop a specification of a production technology, which we refer to as event-specific, that recognizes potential sources of heterogeneity across the production conditions faced by producers, and then we specify a productivity index for that technology and decompose that productivity index into an efficiency index, a technical-change index, and a heterogeneity or event index. A data envelopment analysis representation of the event-specific technology is then developed, and it is applied to our panel data sets.

The empirical results reveal that in both intertemporal and intratemporal productivity comparisons, the heterogeneity or event index is an important component explaining productivity growth and differences. Productivity and efficiency of pesticide use should therefore be measured in a way that incorporates the stochastic element of production and policies should be proposed according to the specific conditions that regions or individuals face. Ignoring these differences would lead to policies that not only fail to support efficient pesticide use, but even alter their optimal use by farmers who are incorrectly characterised as inefficient.

The dual farm model for productivity measurement indicates the indirect role of pesticides on reducing yield variability, connecting the primal and dual representations of the production technology. The model permits measurement of the pesticide shadow price in farm production, which in turn is used for the measurement of the total factor productivity. The structure and implications of these models have been presented in a series of the project's meetings. Thus, the partners of the project have been supplied with important results required for the completion of their tasks, but they have also provided their feedback so as to support and extend the findings of this work package.

The tasks of this work package also include the empirical estimation of the theoretical models developed and the measurement of the proposed results on the cases of Greece and the Netherlands. Before the empirical application could take place, extensive and specified data collection was required. Specific requirements are met in the stage of data collection, covering various features of the production process along with the identifying factors used to distinguish the stochastic elements that affect the behaviour of producers.

WP2: External costs on farmers' health

WP2 investigated the effects of pesticide use on farm operators' health, as well as on their productivity performance. Extensive pesticide use in agricultural activities has a two-way impact on farm productivity. First, pesticides act as a conventional input protecting plants from harmful pests and promoting farm production growth. Second, the heavy use of pesticides is extremely harmful for farmers' health, and their inappropriate application may cause serious health problems to farmers and hence decrease the productivity levels and the competitiveness of their production practices. The identification of this trade-off between expansion of production due to the use of pesticides and the fall of productivity due to the decrease of human capital has important policy implications and affects farmers' decisions. The question raised is how to quantify these two effects so that the optimal use of pesticides is obtained. WP2 addressed these issues by developing a consistent theoretical and empirical framework to analyse the overall effects of pesticides on farms' productivity. The models were implemented in three case studies, i.e., Greece, Bulgaria, and the Netherlands. The results indicated that pesticides were in total beneficial for the farm production in all case countries but that production growth caused by pesticides was decelerated from a significant impairment in farmers' health. Policies directed to increase the productivity gains from pesticides' use must target at decreasing the health risks rather than reducing the overall pesticides use.

During the first year of the project, a consistent questionnaire was developed for the appropriate collection of primary data regarding the effects of pesticides use on farmers' production and health. The questionnaire was first applied to Greek farmers and was then further sent to the Bulgarian partners in order to carry out a similar primary survey in Bulgaria. After a continuous communication with UNWE partners, the questionnaire has been appropriately adjusted according to the particularities and the requirements of the Bulgarian survey and it was delivered to the Bulgarian farmers. The data obtained from the Bulgarian survey together with the data from the Greek survey were sufficiently elaborated, resulting in the development of analytical descriptive tables. Following the suggestions of the project's partners, a similar data set was also obtained for Netherlands. After a close communication with WU partners, the Dutch data set was drawn from LEI that was responsible for collecting the Farm Accounting Database Network (FADN) database.

The elaboration of the primary data indicated that farmers in all three case countries, i.e., Greece, Bulgaria, and Netherlands, faced important health disorders caused by the extensive use of pesticides. Those disorders were much more intensive for Greek and Bulgarian farmers who applied pesticides without following appropriately the safety guidelines. On the other hand, the associated health problems were of a less importance in Dutch farming, where farmers using fully protective equipment applied pesticides. Next, a health impairment index was constructed in order to quantify the magnitude of the effects of pesticides on farmers' health. The empirical application of the constructed health impairment index in the three case countries gave deeper insights as far as the scale of those health effects and further confirmed the initial findings came up from the elaboration of the primary data.

Furthermore, the empirical results of WP2 suggested that agriculture in all three case countries, i.e., Greece, Bulgaria, and Netherlands, has been benefited in overall by the use of pesticides over the past decade. Increases in pesticides use enhanced farmers' productivity and resulted in production growth. Nevertheless, the production growth caused by pesticides was decelerated from a significant impairment in farmers' health. Hence, policies directed to reduce the health effects of pesticides must target at decreasing the health risks of pesticides rather than reducing the overall pesticides use.

In particular, the results from the Greek survey indicated that pesticides' use accounted for 10.22 per cent of the total productivity growth mainly due to improvements in farmer's health status over the years. The indirect effect (through health impairment) was found to be 0.113 accounting for the 9.65 per cent of total productivity growth, whereas the pesticides using technological change effects were also significant, 7.25 per cent. Given that farms exhibit decreasing returns to scale, the increase of pesticide use did not contribute to productivity improvements. On contrary, the increase in pesticide use by farmers accounted for the 6.68 per cent of productivity slowdown during the 2003-07 period.

In the Bulgarian survey, the use of pesticides was found to affect positively farmers' TFP growth for the 2003-2007 period, contributing 13.18 per cent to it. In particular, the 16.87 per cent of that growth was caused by the direct scale effect of pesticides, while the deteriorations in farmers' health due to pesticides use (indirect scale effect) account for 13.50 per cent reductions in TFP growth. Finally, the pesticides using technical change (Biased TC) underlined the production was estimated to contribute also significantly (9.81 per cent) to TFP growth.

Pesticides use in Dutch crop production was found to account for the 14.11 per cent of the TFP growth. In particular, the 6.57 per cent of that growth was caused by the direct scale effect of pesticides, while the deteriorations in farmers' health due to pesticides use (indirect scale effect) account only for a small reduction in TFP growth (2.10 per cent). Finally, the pesticides using technical change effect (Biased TC) was estimated to contribute significantly (9.64 per cent) to TFP growth.

The above mentioned findings imply that safe application of pesticides, education directed to the appropriate pesticides use, and information provision about the hazards of pesticides' chemical elements along with the associated protection methods could reduce or even eliminate the scale of the pesticides' health effects on production. Moreover, demonstration and training of advanced pesticides technologies could accelerate the mechanization of agriculture and enhance production with various ways (reducing health effect by preventing farmers to come in contact or breathe dangerous chemical elements).

WP3: External costs on the environment

The methodology developed in Work Package 3 has been applied to a policy, which consists of a 20% value-added flat tax on all plant protection products, and a 20% differentiated tax on a limited number of products. The second type of tax is a differentiated tax with plant protection products classed in one of two bands, one taxed and the other not taxed, based on their intrinsic toxicity. The taxed band includes only those plant protection products, which contain pyrethroids as an active ingredient. The environmental effects and economic effects of these policies are estimated for a small catchment area (E21) in Southern Sweden and for a larger region (Östergötland).

The environmental effects are estimated as the change in PTI measured as the deviation from a baseline scenario in the small catchment study area. While it was not possible to scale these effects up in the regional study some conclusions about the effects were derived based on the small catchment study. The economic costs are estimated as the change in the total costs of pesticide used and revenue losses due to increased pest risk exposure in the small catchment and changes based on IO analysis in the region.

The estimated price elasticities of demand for pesticides used in the study are -0.39 for insecticides, -0.52 for fungicides and -0.93 for herbicides. The production response to the two types of tax policies is different. In the differentiated tax scenario a tax increasing the price of pyrethroids by 20% decreases the demand for pyrethroids by 7.8%. The distribution of these reductions depends on how farmers adjust to the new economic conditions imposed by the tax. In the study farmers adjust to the tax by substituting other insecticides for products containing pyrethroids and by increasing production of crops that are less intensive in the use of pesticides containing pyrethroids at the expense of crops that are more intensive in the use of pyrethroids. Under the first adjustment, it is assumed that there is a limited possibility for substituting pyrethroids with other less toxic (and not taxed) insecticides. The second adjustment is made by recalculating the land allocated to specific crops in the catchment. In the flat tax scenario, a 20% tax on pesticides not only decreases the demand of insecticides by 7.8% but also the demand of herbicides by 18.6% and that of fungicides by 10.4%. A flat tax does not alter the relative price of pesticides and therefore there is no substitution between products or land reallocation to take into account.

The production adjustments from an environmental tax on plant protection products that contain pyrethroids described above reduce the simulated PTI value from 434 before the tax to 405 after the tax. This represents a reduction in the environmental risk of pesticide use by 6.6%. The flat tax on all plant protection products reduces PTI from the baseline 434 to 396.6 after the tax. This represents an additional 2.2 % beyond the level of reduction achieved with the differentiated tax. However, the change in associated costs imposed on agricultural is much greater.

The increase in costs for farmers when a tax is introduced includes a direct cost following increased input costs and indirect costs, which are reflected in revenue losses. After accounting for demand changes when farmers input costs after the tax are calculated and environmental tax on pyrethroids is introduced, this increases direct costs by about 0.21%. This corresponds to a change in pesticide input costs of around 84 for the whole study area. On the other hand, input costs when a flat tax is introduced are increased by 8.4%, which corresponds to an increase of EUR 3.386 for the study area.

The increase in input costs lowers the use of crop protection products and this leads to lower crop yields resulting in revenue losses. In addition, the reallocation of land use to specific crops as a result of taxes also lowers revenues. For the differentiated tax scenario revenue losses are calculated using farm trials where crop yield losses when no pyrethroids were applied were estimated. The revenue losses were estimated to be between EUR 2.885 and EUR 5.769 for the entire catchment. The total costs of introducing an environmental tax for farmers in the study area is therefore something between EUR 2.963 and EUR 5.857, which reduces the environmental risk of pesticide use by 6.6%. On average the costs of reducing environmental impacts by one unit of PTI is estimated to be in the range of EUR 102 to EUR 203.

No reliable field trials were available to estimate crop yield losses when herbicides or fungicides are not used. Although crop yield losses for potatoes, wheat and barley when no pesticides are used are available for Northern Europe approximate yield losses when no pesticides are used with data from ecological production. This is because data on ecological production was available which provided crop yield estimation for almost all crops included in the study. This data was adjusted for the region of the study and when compared with the available data on crop production without pesticides, turned out to be a fairly good approximation. Under the assumption that the yield losses are the ones comparable to those for ecological production the revenue losses for the study area are estimated to be EUR 63.791. The total costs associated with a 20% flat tax on all pesticides is EUR 67.177 and the environmental benefit was a decrease in the PTI by 8.8%. On average the costs of reducing environmental impacts by one unit of PTI is estimated to be EUR 1.792. Since revenue losses are estimated with a different method than in the differentiated tax scenario these costs are not really comparable to the costs of a differentiated tax. To make this comparison, approximate crop yield losses when no pyrethroids are used in the differentiated tax scenario are equated with ecological production. In this case the revenues losses are estimated to be EUR 8.034 and the total costs are then EUR 8.118. Thus on average the cost of reducing environmental impacts by one unit of PTI is estimated to be EUR 282, which is considerable less than the EUR 1.792 per unit of PTI from imposing a flat tax.

The regional study takes as a starting point a disaggregated Swedish input-output (IO) table which explicitly models commodities of the agricultural sector. The national IO table was obtained from Statistics Sweden and refers to the year 2005. Swedish agriculture was divided into the commodities milk, cattle, pig, poultry and egg, sheep, mixed livestock, cereals, other crops and forage. To enable such a detailed analysis a method for disaggregating the single agricultural account in the Swedish IO table was developed and applied. To do this the inputs and outputs of all production lines identified in the study were disaggregated. Farm accounting data for Sweden together with sector-specific data from Statistics Sweden and Agriwise were used to determine the purchases and sales of different farm types. Within the framework of the IO table different farm types were allowed to produce more than one output to take the normal heterogeneity of farm production into consideration.

Based on the scenarios from the two tax schemes described in the previous section and the regional and disaggregated IO model for Östergötland the economy-wide impacts were estimated. The mixed model approach was used where changes in revenues, due to the tax are designated as exogenous changes in the values of production in the region. To facilitate this analysis the disaggregated results from the scenarios to commodity groups available in the disaggregated IO model need to be aggregated. All the cereals are grouped together into the commodity "cereals" and other crops are collected in the commodity "other crops". The changes in revenues must then be related to actual production values in the entire region for these commodities to determine the actual value of the "shock". Once this is done the change in regional production of these two commodities together with their respective output and employment multipliers can be used to determine the impact throughout the regional economy. Finally, these results decomposed to determine what sectors are the most affected from this impact.

The adjustment in revenues from flat tax scenario is about 10% larger than for the differentiated tax scenario and this is reflected in the impact throughout the economy. The total impact from applying the flat tax is a reduction in regional output of EUR 8.45 million and would result in a reduction of 109 persons employed in sectors throughout the region. Most of this is felt within the cereal and other crops sectors directly but some indirect and induced effects are felt in other sectors. With the differentiated tax the direct effect is much more limited and hence the total effect throughout the regional economy is limited to EUR 0.756 million. Only 10 persons are affected due to reductions in regional employment, nine of these in the cereals and other crop sectors.

Besides the impact in the region, there will also be some impacts leaking out in the form of reduced imports from other regions in the nation and from abroad. Based on import shares for the agricultural sector nationally and the additional imports deducted in the regionalization process the impact on different imported commodities were calculated. For the flat tax scenario the total impact is expected to be a reduction in EUR 2.97 million whereas in the differentiated tax scenario the reduction estimated to be EUR 0.259 million. In both cases, the commodities affected are the food and beverages sector, the wholesale and commission trade and the chemicals sector (with fertilizers and pesticides). Furthermore, machinery and equipment as well as fuels are affected by reductions in imports. If the effect of the flat tax scenario is disaggregated to investigate which sectors are affected one it can be seen that besides the two arable agricultural sectors the impact is most felt within sectors with strong linkages to agriculture. It is evident that the impact is still small in these sectors with only four sectors experiencing an impact above EUR 0.108 million.

These studies have shown that it is possible to estimate ex ante the environmental and economic effects of a proposed tax policy using the methodology developed within the TEAMPEST project. The study has also demonstrated that targeting by using a differentiated tax on the most toxic substances can have a very large beneficial effect on the environment at a lower cost to producers than a flat tax on all pesticides.

WP4: External costs on consumers

The objective of this work package is to examine the demand of pesticides reduction from a consumer point of view. Over the last two decades, an economic literature on pesticide risk valuation has emerged. The WTP estimates available in this literature typically refer to the negative effects on human health, and the damage to environmental agro-ecosystems. A great part of the food safety literature centres on the evaluation of human health risks associated with the preference of pesticide residues in food, typically using stated preferences approaches. In order to find the most appropriate method for estimating the factors that affect WTP for reduced pesticides use (both for food safety reasons and for altruistic behaviours), this task will involve a comparison of the different approaches used to estimate WTP. This task leads up to a report on consumers' perceptions on health risks derived from pesticide use and on the attachment for the respect of the environment.

We highlight that the use of pesticides and chemicals in agriculture may affect consumer behaviour in several ways. First, pesticides may result in soil and groundwater contamination, which may adversely affect the quality of aquatic and terrestrial ecosystems. If consumers become more aware of these problems, changes may be recorded in consumer behaviour because of food safety or environmental ("sustainability") considerations, or both. Nowadays, the individual consumer faces a trade-off between the utility derived from tastes and characteristics of a product, the utility of behaving "green" and the utility of healthy dieting.

Consumers' willingness to pay (WTP) for reduced use of pesticides in the production of fresh and processed foods is measured. In addition, this work package analyses the efficient way to disseminate the information on pesticides reduction to consumers (brands, signals of quality, different labels, etc.). To make this work, we set up experimental markets in four E.U. countries (France, Greece, the Netherlands, Portugal) using the standard procedures to assess the willingness to pay (WTP) of consumers for various types of certification related to the use of pesticides. The product we chose for our experiments was apples (and apple juice), which is the most widely produced fruit in the E.U. and also the most widely consumed in the countries we selected. Of its characteristics we chose (i) the sensory aspect (taste, aspect, grade, etc.) and (ii) the labelling of products at three different levels of pesticide reduction: a standard level corresponding to compliance with the regulations, total absence of pesticides of chemical origin (corresponding to organic certification) and an intermediate level of pesticide reduction of the order of 50%. This last possibility corresponds to a public or private certification of "Integrated Pest Management" (IPM) system or a geographical indication including an equivalent reduction in pesticides in the production schedule, using a Protecting Designation of Origin (PDO) available in each country. The experiment took place first in France and Portugal and then gaining experience and feedback from the other WPs, Greece and the Netherlands followed. Greece's results have included additional estimates to distinguish further consumer behaviour.

The main purpose of our experiments is to evaluate the relative influence of the reduction of pesticide in the WTP, compared to the influence of other attributes like taste, appearance, etc. These main attributes are "intrinsic" attributes, related to the physical characteristics of the products. However, in the food area, there are a lot of "extrinsic" cues, which are searchable and closely related to the marketing and differentiation strategies of the producers. Moreover, these cues are often linked to a commitment in pesticide reduction. Otherwise, it is well known that the information carried out by the labels could contribute to the comprehensiveness and accuracy of consumer's evaluation of search, experience and credence attributes. In the case of credence attributes, extrinsic cues have an important role to inform the consumers who can believe or give credence to the signals without being able directly to test the credence quality itself. Even if consumers are generally unable to measure quality attributes such as the impact of production practices on environment, they may make inferences about these attributes from extrinsic quality indicators and cues as brand names. In this task, we will particularly work on an experimental market protocol, which will enable us to measure how the quality cues carry information on safety issues and defence of the environment.

The experimental design permits testing of a number of hypotheses concerning the performance of experimental markets as a means of revealing consumer WTP (Willingness to pay) and WTA (Willingness to accept). The raw data generated in experimental markets is a bid for each participant in each market repetition. In this task, statistical and econometric procedures were used to analyse

WTP and WTA data. The strategy analysis is chosen to reflect the nature of information collected in experimental markets and the validation of the hypotheses defined.

We obtain a relatively homogeneous behavior of European consumers. In all four countries, there is a significant premium for apples produced with reduced pesticide use. Premiums are statistically significant. Moreover, the absolute premium for the organic apple compared to all other apples is always significant (in average more than 70% higher than the regular's price). There is also a significant absolute premium for IPM apples compared to regular apples. This premium is significantly less than the premium for organic apples (more than 40% higher than the regular's price). However, the premium is significantly increased when pesticide-use reduction is associated with origin (using PDO certification). The impact of sensory characteristics on WTP is always highly significant (whatever the country or apple variety). However, this feature has a weaker effect than information on pesticide reduction. In all four countries, more information about pesticides reduction has a very significant impact on the WTP for the organic apple.

With this estimation, purchasing behavior and market share can be forecast for the various types of certification. We then show how it can be in the interest of the public authorities (European regulation on pesticide reduction) to anticipate changes in the prices of food products in the final market. Although some pricing (such as that observed in organic farming) is much too high to allow real environmental effectiveness, it is paradoxical to see that some European consumers show a real interest in this type of food (today, organic products are no longer the preserve of a class of sporadic purchasers) and that on the other hand, the prices practiced are out of proportion to the WTP of consumers, even though this is high.

Consequently, for the markedly high levels of consumers' WTP in favor of organic products are not sufficient to deduce that efforts should be directed solely to this mode of production. We show how the intermediate solution of subsidizing "Integrated production" can be just as effective in orienting consumption towards more environmentally friendly products. Moreover the potential price increases of conventional products would not necessarily carry with it a drastic reduction in consumer surplus, which would allow the proposed subsidies to be compensated, to balance the overall budget of the policy. Finally, we show how the price levels seen today in the E.U. do not appear to us to be effective from the point of view of the social optimum and orientation of consumers' buying behavior in favor of more environmentally friendly products. While the prices of organic products are considerably too high for the financial means of consumers (explaining the niche markets for this type of product that are seen throughout Europe), the price levels of conventional products could be raised without penalizing consumers too much in the process. Thus, the taxation of pesticides does not appear to pose major problems if it is transferred wholly or partially on to the price of the product. This taxation would have the advantage of allowing the subsidizing of more environmentally friendly practices, particularly IPM procedures. The latter certification could thus become a new reference for consumers. Finally, we survey the budgetary cost of public policies and consider that the deficit from subsidizing good farming practice should be limited or even compensated by taxing of products using pesticides.

For the socio economic impact of our research, we explain why consumer awareness of food safety and social preferences for improving the environmental sustainability of agriculture have led to the design and application of new policy instruments such as eco-labelling of fresh produce. However, the availability of detailed and disaggregated monetary estimates of individuals' WTP for pesticide risk seem to be crucial to implement such policies successfully. Indeed, WTP information provides a basis for price differentiation according to the type and severity of pesticides risks involved in production.

Moreover, environmental voluntary agreements (VAs) between regulators and polluters are becoming an increasingly relevant environmental policy instrument, thanks to their flexibility and consensual character. These agreements can assume a wide variety of forms and aims. Efficiency conditions and effectiveness in their use depend crucially on the environmental WTP (producers adhere more easily to the VAs if the WTP is high).

We show how European consumers may have relatively uniform expectations vis-à-vis the reduction of pesticides in the fruit and vegetable sector. When this reduction is publicly certified, consumers' willingness to pay increases as a function of the level of reduction. Organic farming is clearly approved of in all the countries and very often enables a doubling of the consumers' WTP. The average premium (difference of WTP between organic and conventional products) is about 96% in Portugal, 72% in France and 68% in Greece. These results are confirmed in experiments in Netherlands. However, in this country, organic production seems to be less valued by the consumers. The average premium for conventional organic certification is only around 11% and 22% for the certification "Organic plus".

Moreover, we show how certifications, which do not guarantee a drastic reduction of pesticides (namely certifications with "Integrated Pest Management"-IPM- system), do not yield to such significant results. However, there is a significant absolute premium for IPM compared to regular products. This premium is less than the premium for organic apples (but in average more than 40% higher than the regular's apple) and increases significantly when pesticide-use reduction is associated with origin (using PDO certification). Note that the impact of sensory characteristics on WTP is always highly significant. However, the influence of sensory characteristics does not change the hierarchy of prices when consumers are informed on pesticide reduction. The last qualitative result is on more information about pesticides reduction: it appears that informing participants on pesticide-use reduction has a significant impact on the WTP but entails a significant decrease of the WTP for the regular products (safety information can have both positive and negative effects). Thus, more information leads to a change in the reference point of the consumers.

In all European countries, more information about pesticides reduction has a very significant impact on the WTP for the organic products. For the IPM strategy, improving information about pesticides reduction has no significant impact on the WTP. However, information about pesticides' reduction has a significant negative impact on regular products. Indeed, while the labels may convey positive messages to consumers about the production conditions, they may simultaneously stigmatize the conventionally produced products by highlighting perceived problems related to pesticide residues. The net economic result for producers can be negative since consumers may decrease their WTP for conventional products that dominate the market. However, the assessment of environmental friendly consumption is improved, without excessively penalizing the consumer surplus.

Using a multicriteria approach in the area of public economics, we highlight the following policy recommendations:

i. Strengthen communication to consumers about the efforts of producers in reducing pesticide (Information policy through the use of labels may affect producers' decision to reduce pesticide use).
ii. Develop public qualifications related to IPM (Despite their efficiency, these logos are really not very present in EU).

iii. Imagine public regulation in order to change the ratio of prices and to redefine the market benchmark (Subsidizing organic farming could help given the high WTP of many consumers for organic products, taxing pesticides but subsidizing IPM).
iv. Do not be limited to the use of a single regulatory tool. Relying on interactions between policy tools (tax, subsidy and information) would be an efficient way to reduce pesticide use at a low cost for the public budget.

With the results that we have obtained with the experimental market during the TEAMPEST project, we can confirm that it is possible to assess the alternatives for having consumers contribute in favor of improvement to environmental practices. We have in particular shown that the certification and labeling of products with these types of characteristics are necessary to have consumers make their choice. However, improving public information in this domain would favor the catalyzing role of responsible social behavior. The estimation of WTP (through experimental procedures) is fairly convincing, especially since consumers' behavior across the European territory is seen to be highly homogenous.

WP5: Tax and Levy Schemes

An interpretive review of the literature in support of the work package on "Economic Sustainability, Biodiversity Loss and Socially Optimal Pesticide Use" has been undertaken. Particular attention was focused on the interaction between production decisions and biodiversity loss, reduction of environmental quality and impacts of agricultural and environmental policy on pesticides use. Based on an overview of existing systems for regulating pesticide use, a dynamic model of socially optimal pesticide use was developed to reveal the impact of pesticides' biodiversity externalities on output realization and input use. The same modeling framework was used to assess the effectiveness of different tax and levy schemes in reducing pesticide usage and externalities. Pesticide contribution on biodiversity was found to impact farm output significantly. Pesticide taxes as a single instrument can be characterized as ineffective due the fact that they yield small decreases in pesticide use and environmental impacts. Pesticides taxes have negative effects on income, which can be reduced though by returning the revenues to farmers as lump sum payments. Also, negative consequences on income can be reduced by investing the tax revenues in the development of more environmental friendly products or more productive pesticides. However, no single tax or levy instrument can lead to a substantial reduction of pesticide use.

The main S&T results/foregrounds are:

- Over 220 scientific publications and reports reviewed and several organizational directions were undertaken. Each publication was reviewed along a set of common criteria: a) abstract, b) setting, c) modeling framework, d) data, e) applications, and f) results and policy implications. The review has been developed across three major themes: a) Economic growth and the environment, b) pesticides and biodiversity and c) pesticide policies with a view toward identifying the important results, gaps, overlapping results and policy implications.

- A dynamic organization of the literature in a web-based map took place. The user can scan through the outline to obtain a brief description of each theme and sub-theme, and follow the branches to view the relevant literature in terms of the six common criteria identified above. The final component of this work is a spreadsheet that organizes the literature along these same criteria than can provide a means for rapidly searching for keywords.

- A dynamic model of socially optimal pesticide use has been developed based on findings from the interpretive literature review.
- Concerning the data available for this work, FADN data on the use of inputs, supply of outputs, detailed data on pesticide use at the farm level and impact points of pesticides on the environment have been acquired by LEI. The environmental impact points of the different pesticides have been connected to the detailed pesticide data at the farm level.
- The compilation of the data set on FADN and pesticides data that was started in the first reporting period has been completed (task 5.4).
- A number of tax and levy systems have been designed, targeting different types of pesticides and environmental impacts. The tax and levy schemes have been reported in D5.2. (task 5.2).
- The conceptual dynamic model of decisions on pesticides use, output supply and use of other inputs (developed in task 5.3 in the previous reporting period) has been estimated using FADN data of the Netherlands. The results have been analysed and reported in D5.3 and 5.4 (task 5.4).
- A simulation model was developed in GAMS, based on the results of the estimation of the empirical model for the Netherlands. The simulation model is used for simulating the impacts of different pesticides tax and levy schemes on output supply, input demand, pesticides use and environmental impacts. The results of the simulations have been reported in D5.4 (task 5.4).
- A dataset including farm level data for Dutch cash crop producers was constructed for the needs of WP2.
- Coordination with WP6 took place. More specifically, the results of the econometric estimation of the dynamic model in 5.3 were communicated with WP6 in their effort to use robust parameter estimates for biodiversity in their simulation process. Simulation results at the farm level for the Netherlands in 5.4 were also discussed with WP6 partners to identify common grounds with their simulation results at the country level.
- Coordination with WP8 took place in order to assist them in applying the simulation model used in The Netherlands to Bulgaria and Portugal.

WP6: Optimal Tax and Levy Policy

The use of pesticides in modern agriculture has without a doubt aided worldwide farmer productivity. However, extensive use of chemical plant protection products has resulted in numerous side effects causing harm to both the environment, and the health of farmers and consumers. To prevent this, measures and policy tools are implemented throughout the European Union so that the use of these products is brought down to a sustainable level. Deliverable 6.1 provides a detailed presentation of such measures and policies implemented both at a national and at a EU level and, in addition, it discusses economic incentive schemes (taxes/levies/subsidies etc.) implemented inside and outside the European Union toward the sustainable use of plant protection products. Deliverable 6.2 focuses on the development of a realistic and effective tax and levy scheme that reduces the use of pesticides to a socially optimal level from the point of view of a policy maker, who takes into account the negative effects of pesticide use on consumers, farmers, and the environment and the positive effects of pesticide control inputs to the agricultural production. This work has led to the creation of a formula, which allows for the estimation of an optimal tax rate, on the price of pesticides, while taking into consideration all the externalities associated with their use. Deliverable 6.3 extends the previous model by providing a lower bound or threshold below which any proposed tax should not fall. This is done because of the fact that an additional externality, which arises due to biodiversity loss, must be reckoned with. Lastly, Deliverable 6.4 presents the simulation estimations for the optimal tax rates on the price of pesticides using data for Cyprus, the United Kingdom and the Netherlands.

The collection of detailed data on pesticide use and their environmental impacts across the EU member states should be encouraged. Such data may enable policy makers to introduce socially optimal pesticide tax and levy schemes in order to tackle the problem of pesticide externalities. These schemes can alter pesticide decisions at the farm level such that negative externalities of pesticides are reduced. Pesticides are overused in Dutch arable crop production while pesticides' contribution to biodiversity is found to impact farm output significantly.

Pesticide taxes as a single instrument can be characterized as ineffective due the fact that they yield small decreases in pesticide use and environmental impacts. Pesticide tax schemes that put higher penalties on high toxicity (HT) than low toxicity (LT) pesticides do not result in a substitution between the two. This implies that HT pesticides are important to farmers and that there is a lack of effective LT alternatives. Pesticides taxes have negative effects on income, which can be reduced though by returning the revenues to farmers as lump sum payments. Also, negative consequences on income can be reduced by a levy system that invests the tax revenues in the development of more environmental friendly products or more productive pesticides. However, no single tax or levy instrument can lead to a substantial reduction of pesticide use.

In general, Deliverable 6.3 analyzed the problem of a negative externality that arises in the context of a dynamic model that can be viewed as an extension and as complementary to the dynamic macroeconomic model developed in Deliverable 6.2. The nature of this externality is measured as a percentage of lost output that can arise due to pesticide resistance that results in a suboptimal plant-pest mix with adverse consequences on environmental quality and overall ecosystem value. The main modeling tool adopted here is the Bellman equation that characterizes the optimal control problem at hand. We assign values at two different ecosystem management choices: one where the dynamic externality of pesticide resistance is ignored and one where it is internalized (it is fully taken into account). The difference in the two valuation functions gives us the measure of the cost that arises due to this externality.

More specifically, Deliverable 6.1 measures and policy tools aiming to control excessive pesticide use can be classified into those which target the farmer, the consumer, the environment, and overall reduction of pesticide use. A wide array of such measures is implemented in EU Member-Countries. In addition, economic instruments and incentives such as tax/levy/fee systems are used throughout the EU for the same purpose. Deliverable 6.1 reports on these topics with focus on the EU. Additionally, aggregate data on the use of pesticides in Cyprus, Bulgaria and the UK have been collected from various sources.

Deliverable 6.2 resulted in the development of an aggregate economy model, which embodies the negative effects of pesticide use on the consumers, the producers, and the environment. On the production side, pesticide use has a negative effect on farmers' productivity through the negative effects of pesticide use on farmers' health. To the extent that farmers underestimate these health effects of pesticide use, a negative externality is introduced in the production side. As a result, the decentralized choice of pesticide use is greater than its socially optimum level. On the consumption side we assumed that consumers care about the quality of the agricultural good consumed, and the quality of the environment, both of which are negatively affected by the use of pesticides. In a decentralized economy, farmers choose the amount of pesticides that maximizes profits without taking into account its negative externality on the utility of the consumers. In order to reach a socially optimum solution, a tax on the price of pesticides was introduced in the decentralized economy. This socially optimum tax internalizes all three negative externalities from pesticide use introduced in our macroeconomic model. In addition, tax revenues must be transferred to the consumers in a lump sum manner, in order for the whole economy to reach its socially optimum outcome.

According to the main results of Deliverable 6.3, the decentralized choice of pesticide use is greater than its socially optimum level. The magnitude of the discrepancy between the SOM (social optimal management) and the POM (private optimal management) ecosystem is found to be on average about 10 percent in terms of lower long-run harvest, using a wide range of values for technological and ecological parameters. In the previous task 6.2, in order to reach a socially optimum solution, we introduce a tax on the price of pesticides in the decentralized economy. This socially optimum tax internalizes the negative externality effects from pesticide use introduced in the macroeconomic model. In addition, it is argued, that tax revenues must be transferred to the consumers in a lump sum manner, in order for the whole economy to reach its socially optimum outcome.

The main policy implication of the Deliverable 6.3 is that there is an additional externality to reckon with that is due to biodiversity loss. The implication here is that we derive a lower bound to the externality tax that is obtained in the previous task 6.2 and as such we deliver a threshold below which any proposed tax should not fall. We find this lower bound or threshold to be ten percent. This threshold identifies the magnitude of the biodiversity externality, against which we are able to measure the tax correction of the macro economic externalities of the previous task.

Finally, the results of Deliverable 6.4 suggest that based on the various specifications of our model, the (base year) tax rate estimates range from 3.19% to 31.88% for Cyprus, from 2.47% to 24.73% for the UK, and from 7.59% to 75.92% for the Netherlands. For the latter country case we remain skeptical as to the credibility of the results because of several difficulties encountered in retrieving the data for pesticide use.

In addition to our basic estimations, we further alter some of the parameters of our model to provide additional estimations of the optimal tax rate. These additional simulation results range from 47.83% to 79.71% for Cyprus, from 37.09% to 61.82% for the UK and from 113.89% to 189.81% for the Netherlands (base year results).

Furthermore, with regard to the design of a levy scheme, this deliverable calculates the revenues the government would generate if it were to enforce the calculated tax rates. Again, this is performed for all country cases and for all model specifications. The results range from EUR 450,000 to EUR 4 million for Cyprus, from GBP13 million to GBP127 million for the UK, and from EUR 30 million to EUR 247 million for the Netherlands.

WP7: Incentives for pesticide substitution

The work carried out by UWA in the TEAMPEST project focused primarily on identifying the socio-economic drivers for the choice of farm system strategies, particularly with respect to the use of plant protection products. Financial performance is often considered the main driver of farmer decision making but other drivers include attitude to risk and the environment, the natural resource capacity of the farm, social factors such as attitudes of friends and colleagues, sources of information and support and the broader policy environment in which farmers' farm. The work carried out by UWA in TEAMPEST was to investigate arable and horticultural farmers' willingness to adopt low pesticide farming systems. This was done by undertaking a literature review on farmer decision making to identify the relative importance of financial performance compared to other drivers of decision making; carrying out an analysis of the relative profitability of low, medium and high plant protection product use farms with organic across the EU; and finally by undertaking a series of farmer focus groups in case study countries to ask farmers how the introduction of a tax or levy on pesticides may or may not change their farming behaviours.

More specifically, the main results by task are:

- Task 6.4 carried out the empirical estimation of the optimal tax for three country cases: Cyprus, the United Kingdom and the Netherlands. The estimated tax rates (percentage tax on the price of pesticides) for the United Kingdom, under various assumptions and specifications of the model parameters, ranged from 2.47% to 24.73%. The full results for the UK case study are presented in Deliverable 6.4.

- Task 7.1 highlighted the importance of other drivers to the uptake and persistence of low input farming practices such as attitude to risk and the environment, the natural resource capacity of the farm, social factors such as attitudes of friends and colleagues and sources of information and support and the broader policy environment in which farmers' farm. Full details can be found in Deliverable 7.1

- Task 7.2 and 7.3 highlighted the variability in Crop Protection (CP) usage both between farm types and crop enterprises, but also the variation within these groups.

At whole farm level, conventional high CP use holdings were the most profitable and the largest economically, with variable performance on organic holdings.

At crop enterprise level, results were more variable with organic enterprises achieving the highest gross margins, but within conventional farming high CP use systems were generally (but not exclusively) the most profitable.

The imposition of the tax/levy on crop protection inputs resulted in a reduced difference in profitability between low, medium, high CP input and organic groups, but didn't alter the overall position that higher input systems resulted in higher profitability per hectare.

Therefore it can be concluded that a flat rate tax/levy would probably not achieve a potentially desirable shift of farmers from high input to lower input or organic systems, due to the lower profitability of low input systems and a lack of new organic markets. Full details can be found in Deliverable 7.2.

- Task 7.4 focus group work found that a tax on crop protection costs, like that outlined in the scenarios presented in this study is unlikely to result in a decrease in the use of crop protection products or a significant change in the way high input farmers' farm. It is very unlikely, given these results that farmers would move from high input crop protection systems to low input or organic systems for the reasons outlined in this report.

With respect to policy recommendations, it was very clear in both BG and UK that technology was viewed as the key driver to farming practices of the future and also to how the use of crop protection products could be reduced. All farmers were keen to see investment at the EU and national level in technology development, and in the UK specifically look at the alternative technologies such as GM and its potential for reducing chemical use in farming. NL farmers also thought that R&D to develop novel pest and weed control products and techniques was important, but the farmers in these groups identified a much wider range of factors that will influence their farming practices in future - particularly mentioning the powerful role of retailers and multinational chemical companies in influencing their farming practices.

Suggestions were made by the farmers during the focus groups of how a reduction in pesticide usage could be achieved voluntarily by encouraging better practice rather than financially penalizing for the use of pesticides. Full details can be found in Deliverable 7.3.

- Task 9.1 resulted in the production of a short a report on the External Costs of Pesticides in the UK. The main conclusion of the report was that there is no publically available comprehensive study that looks at the external costs of pesticides to society in the UK. In 2005 Pretty (ed) and colleagues published a book called The Pesticide Detox: Towards a More Sustainable Agriculture, which included chapters on the external costs to the environment and to consumers of pesticides, however this was not confined to UK examples. In an earlier publication (Pretty et al., 2000), the external costs of agriculture in the UK were estimated, including the costs of pesticide pollution of waterways and the cost of pesticide poisonings (acute and chronic cases in operators and general public). Whilst these figures are now quite old, the study puts monetary values on these costs (e.g. the annual capital expenditure by water companies on pesticide removal between 1992 and 1997 was GBP124.9 m/year after depreciation (at 1996 prices)). The Food and Environment Research Agency (FERA) undertakes research for both the public and private sector and their role is to support and develop a sustainable food chain, a healthy natural environment, and to protect the global community from biological and chemical risks. This organisation has published a wide range of papers on the environmental and health costs of specific pesticides and the list of these publications can be found on their website (http://www.fera.defra.gov.uk).

WP8: Implementation policy recommendations

The optimal tax level on pesticides use in both case study regions are estimated on the basis of the approach suggested by UCY. Some amendments in the model proposed are done due to some specifics of the analysed countries. The period in the analysis is 2002 - 2008, and the optimal tax for each case study is estimated as an average for the period. In addition to the Bulgarian and Portuguese case studies the optimal tax level is estimated for France, Germany, Poland and Hungary. The optimal tax levels on pesticides use obtained in all analysed cases are generally low, less than 50%, and are highly dependent on the assumption of the effect of pesticide use on the final consumption of agricultural good and not so much dependent on the assumption of the effect of the consumption of the agricultural good on overall utility and to the effect of environmental quality on overall utility. This practically means that consumers would value much more the effect of reduction of pesticides use on final consumption of agricultural goods than other external effects of pest use. For the cases of Bulgaria and Portugal we have to consider that the highest level of the effect on consumption for which the tax level is estimated is 1%, or in other words the tax level in Bulgaria should be established at 14% and thus increasing the price of pesticides used by 14% and in Portugal - at 31% leading to an increase in prices of pesticides by 31%.

The optimal tax level estimated for the two case study regions are used to evaluate the impact of tax introduction on farm level. The impact is evaluated on the basis of the model developed by WUR and some amendments are done in model due to data availability. The study shows that the effect of introduction of tax at farm level is relatively insignificant if the level of the tax is less than 50% in Bulgaria and less than 20 % in Portugal. More substantial impact could be expected in respect to the cost of pesticides in case of tax higher than 50% in Bulgaria and 20 % in Portugal. The high taxes are needed to achieve significant reduction in use of pesticides. The impact of tax introduction depends on specialization of the farms. It is higher in the cases for farms with orchards and vineyard specialization.

Having in mind that generally the use of pesticides is relatively inelastic to the price of pesticides, which has been proven by the two case studies performed imposing tax less than 50% for Bulgaria and less 20% for Portugal would not lead to substantial reduction of pest use and as the share of costs for pesticides in total cost on production (8 - 10% though the period 2002 - 2008 on average for agriculture) this increase in price of pest would lead to relatively low increase (less than 2% in case of Bulgaria and less than 3% in case of Portugal) in the total cost of production and that will not lead to a substantial reduction in pest use. Therefore in two case study regions the effect of the introduction of tax on pesticides use on a socially optimal level is doubtful.

Potential Impact:

Potential impact and the main dissemination activities and exploitation of results

The TEAMPEST project has included numerous dissemination activities to the scientific community, to policy makers, to stakeholders and to the broader public, at the regional, national, European and international level. All deliverables, with the approval of the Scientific officer, have been made publicly available through the project website to facilitate dissemination of results. Furthermore, each deliverable is accompanied by an extended summary and policy related results that make exposition of the empirical results and policy recommendations easier to apprehend for the widest possible audience. Extensive interaction and feedback from consumer groups' representatives, private industry stakeholders and health officials have greatly improved the work throughout the project and the quality of the deliverables. In addition, a leaflet (Extended Policy Brief) was developed presenting the main findings and policy recommendations of the TEAMPEST project, translated in all partners' languages, distributed to a very large audience, and national stakeholders. These findings and policy recommendations were also presented in a seminar held in Brussels, Belgium, and attended by a wide audience, including policy makers, EU officials, the scientific community, private industry stakeholders, consumer groups' representatives, and journalists. Finally, the TEAMPEST methodologies and results were disseminated through a number of seminars, conferences, stakeholder meetings, scientific journals, and through the organization of professional practical trainings, scientific practical trainings and a short course. A European EAAE seminar has been organized having as a particular theme the external costs in agriculture, where a broader audience of scientists working with pesticides attended. Finally, a special issue in Food Economics is under publication devoted on the conference's theme. In what follows, the main dissemination activities and exploitation of results by WP are presented.

WP1-2

During the first year of the project, a questionnaire was developed in WP2 with emphasis on the effects of pesticides use on farmers' health status. The questionnaire developed on the basis of literature, existing data, but also with a close collaboration with experts and health officials. The questionnaire was distributed to Greek farmers, while a slightly modified version of it was also delivered to Bulgarian farmers after a strong collaboration with UNWE partners. During the fulfillment of the questionnaire, the farmers in Greece and Bulgaria were informed by the interviewers about the health hazards of pesticides. The interviewers provided also information to the respondents about the safe application of the pesticides and the importance of using full protective equipment during the application. Finally, the farmers were also informed about which chemical elements are more dangerous for their health.

The main dissemination activities took place during the project time period as far as WPs1-2 are:

- The theoretical and empirical models developed under WP1 and WP2 were presented in the 6th European Workshop on Efficiency and Productivity Analysis. The conference was held in

Pisa (Italy) on June of 2009. In addition, the theoretical models were presented at the VI North American Productivity Workshop in Houston, Texas, USA.

- Deliverables 2.2 and 2.3 constituted parts of the thesis of a doctoral student, Konstantinos Chatzimichael, who was participating in the TEAMPEST project.
- A working paper analyzing the health effects of pesticides on farmers' productivity have been uploaded on the official website of university of Crete (department of Economics)
- Paper presentations of the models developed and the empirical results of WP1 and WP2 in the 120th EAAE Seminar (Crete, Greece), the 2011 EAAE Congress Change and Uncertainty (Zurich, Switzerland), Nomisma Societa di Studi Economici (Rome, Italy), Cemagref and SFER Conference (Lyon, France), ETAGRO Biannual Conference (Athens, Greece), International Atlantic Economic Conference (Athens, Greece), EU Conference "For a competitive food supply chain in Europe" (Brussels, Belgium), Policymakers' meeting (Beograd, Serbia)
- Organization of a Pre-Congress Symposium in Zurich, Switzerland to disseminate the models, results and policy recommendations
- Several contacts and presentations of results to local companies, regional and local organizations, scientific community and policymakers (Hellenic Ministry of Agriculture, Geotechnical Chamber of Greece, Agricultural University of Athens, University of Thessaly, Geotechnical Association of Thrace, University of Ioannina, Democritus University of Thrace, University of West Macedonia, Technical College of Florina)
- Participation in the short course on "Theoretical Models and Empirical Measurement of the External Cost of Pesticides" in Wageningen, Netherlands

WP3

The focus of Work Package 3 is on the impact on the environment from pesticide use in agriculture. The first deliverable from this WP is a review on the use of environmental indicators for pesticides. This report concludes that the use of a simple risk indicator developed in Sweden for monitoring purposes, the Pesticide Toxicity Index (PTI), represents a good indicator for ex post policy analysis. In the second deliverable from this WP (Deliverable 3.2), the PTI and the bio-physical model MACRO, are combined to capture the path of pesticides from their source of application (fields) to the aquatic environment. This approach is used to assess the environmental impact of different pesticide tax policy scenarios. The WP then uses economic analysis to assess the economic impacts on farmers of these policies. In an ex post policy comparison it is shown that the environmental risk reduction of a 20% tax on pyrethroids, a group of very toxic insecticides, is very close to the risk reduction of a 20% environmental flat tax on pesticides. However, since the tax burden on farmers introduced by the flat tax is much larger, this suggests that the differentiated tax is much more cost efficient in reducing environmental risks from the use of pesticides.

These results are of interest for the development of Swedish environmental policy. The methodology proposed in WP3 offers a tool for policy makers to ex ante evaluate policy alternatives. The results from Deliverable 3.2 are also particularly interesting for the use of environmental taxes on pesticides. A simple differentiation of the environmental tax, similar to the tax on pyrethroids introduced in

Deliverable 3.2, may reduce environmental risks at much lower costs to farmers then non-differentiated taxes. The study performed by the TEAMPEST project shows that although differentiation marginally increases administrative costs, it may lead to a more cost effective environmental policy than the current flat tax on pesticides in Sweden. When the FOOTPRINT tools (see http://www.eu-footprint.org/) become available, it will be possible to apply this methodology in broader ex ante policy analyses, in Sweden, and in other EU member states.

Work Package 3 represents a contribution to understanding how taxes and levies can be used to reduce the external costs associated with pesticide use in agriculture. The foundation provided by this program will make it easier for policy makers in Sweden to perform ex ante analysis of policy alternatives and their impacts on operator health, productivity, the environment and consumers.

The main dissemination activities took place during the project time period as far as WP3 are:

- Seminar on the WP3 results and the TEAMPEST project results, Department of Soil Sciences, SLU, Sweden
- Presentation at the FoSW symposium Ecosystem services in soil and water research, Uppsala, Sweden
- Presentation at the 6th Biennal Conference of the United States Society for Ecological Economics, East Lansing, Michigan, USA
- Presentation at the Pre-Congress Symposium on the External Costs of Pesticide Use in Agriculture in Zurich, Switzerland
- Presentation to national policymakers of the results of WP3 and TEAMPEST, Stockholm, Sweden
- Participation in the short course on "Theoretical Models and Empirical Measurement of the External Cost of Pesticides" in Wageningen, Netherlands

WP4

Consumer awareness of food safety and social preferences for improving the environmental sustainability of agriculture have led to the design and application of new policy instruments such as eco-labelling of fresh produce and regulations for the proper use of pesticides and optimal pesticide taxes. The availability of detailed and disaggregated monetary estimates of individuals' WTP for pesticide risk is, however, crucial to implement such policies successfully. In the case of an ecological tax, tax requires the eco-tax to be set equal to the marginal value of the negative externalities associated with pesticide use. In the case of eco-labelling, WTP information provides a basis for price differentiation according to the type and severity of pesticides risks involved in production. Moreover, environmental voluntary agreements (VAs) between regulators and polluters are becoming an increasingly relevant environmental policy instrument, thanks to their flexibility and consensual character. These agreements can assume a wide variety of forms and aims. Efficiency conditions and effectiveness in their use depend crucially on the environmental WTP (producers adhere more easily to the VAs if the WTP is high).

We can confirm that it is possible to assess the alternatives for having consumers contribute in favour of improvement to environmental practices. We have in particular shown that the certification and labelling of products with these types of characteristics are necessary to have consumers make their choice. However, improving public information in this domain would favour the catalysing role of responsible social behaviour. Moreover, socio-professional categories play a significant role in the consumers' behavior. For example, the premium for organic products is more important for women, for young people (20-29 years), for high education level and presence of children in the household. However this is not the income that expresses the premium given to the WTP for pesticide reduction, and it seems that "organic consumers" doesn't exist anymore, in the sense that, today, anyone is a buyer of such products.

The main dissemination activities took place during the project time period as far as WP4 are:

- Presentation of main WP4 results and theoretical developments at the University Technique of Lisbon, Portugal and at INRA- Ivry sur seine, France
- Professional practical training based on TEAMPEST findings in INIA, Oeiras, Portugal
- Scientific practical training on techniques of measuring consumers' willingness-to-pay in INIA, Oeiras, Portugal and in University "Nova" of Lisbon, Portugal
- Paper presentations at the VI Congress of the Portuguese Agricultural Economics Association in Azores, Portugal; 28th International Horticultural Congress in Lisbon, Portugal; 120th EAAE Seminar in Chania, Greece; Workshop on traditional and mountain products in Ourique, Portugal; Conference grand public in Roissy, France
- Participation in the short course on "Theoretical Models and Empirical Measurement of the External Cost of Pesticides" in Wageningen, Netherlands
- Paper presentations at the ETAGRO Biannual Conference (Athens, Greece), 71st International Atlantic Economics Conference (Athens, Greece)
- Presentation at the Pre-Congress Symposium on the External Costs of Pesticide Use in Agriculture in Zurich, Switzerland

WP5

The collection of detailed data on pesticide use and their environmental impacts across the EU member states should be encouraged. Such data may enable policy makers to introduce socially optimal pesticide tax and levy schemes in order to tackle the problem of pesticide externalities. These schemes can alter pesticide decisions at the farm level such that negative externalities of pesticides are reduced. Pesticides are overused in Dutch arable crop production while pesticides' contribution to biodiversity is found to impact farm output significantly.

Pesticide taxes as a single instrument can be characterized as ineffective due the fact that they yield small decreases in pesticide use and environmental impacts. Pesticide tax schemes that put higher penalties on high toxicity (HT) than low toxicity (LT) pesticides do not result in a substitution between the two. This implies that HT pesticides are important to farmers and that there is a lack of effective LT alternatives. Pesticides taxes have negative effects on income, which can be reduced though by returning the revenues to farmers as lump sum payments. Also, negative consequences on income can be reduced by a levy system that invests the tax revenues in the development of more environmental friendly products or more productive pesticides. However, no single tax or levy instrument can lead to a substantial reduction of pesticide use.

Description of the potential impact (including the socio-economic impact and the wider societal implications of the WP and project results so far) and the main dissemination activities and exploitation results

This WP has the following potential impacts

1. This WP helps in designing more effective pesticides tax and levy systems. This work has shown that even very high pesticide tax rates may lead to small pesticide reductions. A levy scheme that reinvests tax revenues in research towards less toxic pesticides may be more effective in decreasing pesticide use and its related externalities.
2. This WP has shown that more detailed data on pesticides use and pesticides externalities can be helpful in designing and implementing pesticides tax and levy systems.

The main dissemination activities took place during the project time period as far as WP5 are:

- Paper presentation of WP5 theoretical models and empirical results in the 120th EAAE Seminar (Chania, Greece); Pre-Congress Symposium (Zurich, Switzerland)
- Presentation of main WP5 results and policy recommendations to policy officers and researchers in a Meeting of leaders and strategic projects on sustainability, in Wageningen, Netherlands
- Participation in the short course on "Theoretical Models and Empirical Measurement of the External Cost of Pesticides" in Wageningen, Netherlands

WP6

The results of WP 6 will have potential impact and use primarily in terms of policy design. The findings of this work will potentially serve as a tool for future implementations of tax and levy systems for pesticide use within the EU and perhaps provide the basis for modifications in existing European policies. The models developed towards for estimation of the optimal tax and levy scheme may serve as background for future design of similar schemes. In addition, the results from the empirical estimations can help as guidance towards the level of taxation that is required.

Until now, the results obtained from Deliverable 6.1 have contributed to a publication from the Economics Research Centre of the University of Cyprus:

Gregoriou P., T. Mamuneas and P. Pashardes, "Agricultural Support Policies and Optimum Tax and Levy Scheme for Pesticide Use in Farm Production", Economic Analysis Paper No. 03-09, Economics Research Centre, University of Cyprus, July 2009.

In addition, the paper "Optimal Tax on Pesticide Use in Farm Production: A Dynamic Macroeconomic Model", by Pantelis Kalaitzidakis, Theofanis P. Mamuneas and Thanasis Stengos, will be sent for publishing soon and will also be presented in the forthcoming TEAMPEST pre-Congress (XIIIth EAAE) Symposium in Zurich, Switzerland.

Furthermore, WP6 partners have participated in the short course on "Theoretical Models and Empirical Measurement of the External Cost of Pesticides" in Wageningen, Netherlands

WP7

The work carried out in WP7 is particularly relevant from a social and economic impact point of view within TEAMPEST. The TEAMPEST project as a whole provides an assessment of the external costs of agricultural pesticide use (particularly in terms of the environment and human health) and has developed tools for designing socially optimal tax and levy schemes aimed for use by EU policy makers to implement to reduce pesticide use to its socially optimal level. Work package 7 however, looks at the farmer behaviour and decision making in the face of such tax and levy systems being introduced. In order for EU policies to be successful in reducing pesticide use to socially optimal levels, farmer behaviour must be influenced as predicted by the introduction of a tax or a levy. Taxes and levies on pesticide use tend to assume that financial performance is the key driver to decision making with respect to pesticide use in farming, however, the results of the focus groups show that the introduction of taxes and levies on pesticides is unlikely to change farmer behaviour. This is because there are a large number of other factors influencing farmer decision making, the predominant theme arising being risk if pesticides are not used (e.g. financial, crop quality, yield etc). There was also perceived to be a lack of technology currently available for farmers to be able to reduce pesticide usage and still meet yield and product quality demands put on them externally by the markets, and to make a living. The financial analysis presented to farmers showing the impact on farms similar to their own if a tax or levy was introduced was not enough to sway farmers to change their practices - the risks of not using pesticides was seen to outweigh any extra costs resulting from the tax or levy.

The key implications to come out of Work package 7 are that it is clear that the introduction of a tax or levy on pesticides will not change farmers' behaviour in terms of use. A more positive approach of EU and national investment in the development of new technologies and varieties for growing without high levels of pesticides and incentive schemes for low input and organic systems were identified by farmers as being the way to change farmer behaviour - the carrot approach as opposed to the stick.

The main dissemination activities took place during the project time period as far as WP7 are:

- Production of three scientific papers based on the three deliverables of Work package 7 and linked with other work package results
- Outcomes and policy recommendations from this work package were also be presented to the Commission on the 6th June along with the other outcomes from TEAMPEST.
- Participation in the short course on "Theoretical Models and Empirical Measurement of the External Cost of Pesticides" in Wageningen, Netherlands

WP8

The main dissemination activities took place during the project time period as far as WP8 are:

- A policy seminar was held in Sofia, April 2011. All the findings of work package 8 were presented on the policy seminar and were discussed between policy makers, agricultural producers and researchers.
- Presentation at the 2011 EAAE congress, Zurich 2011.

List of Websites:

Project Public Website

The website address is http://teampest.agro.auth.gr

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