

Potential economic effects of climate change on Finnish agriculture

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In the assessment of the economic effects of climate change, changes in returns and costs have to be taken into consideration. Changes in returns are mainly caused by changes in the yield level. Costs are determined by various factors. Harvesting conditions may improve as the temperatures are higher. However, an increasing need for disease and pest control results in higher costs. Various extensive studies have indicated that rising temperatures with the CO₂ fertilizing effect increase the crop potential in Finland. From the economic point of view an increase in yield level is highly significant, because the increase in costs remains quite small. A 10% increase in the yield level raises the farm income by about 6%. Because agriculture is supported in many ways either directly or indirectly, the rise in income level may be offset by lowering the support. Consequently, farmers may not benefit from an increase in the yield level, but the benefit will go to the state economy. However, an increase in the yield level resulting from rising temperatures is advantageous to the national economy, regardless of whether the benefit goes to the farmers or to the state.

Key words: policy changes, welfare effects

Introduction

The economic effects of climate change result from consequent changes in the yields of cultured plants. In the case of Finland, recent studies of the SILMU programme (Mela et al. 1996) indicate that crop yields will increase, i.e. the yield function will shift upwards. This has a direct positive effect on the economic result at farm level. However, there are also potential losses due to crop pests and diseases which have to be taken into account.

In addition to changes in quantity, economic analysis requires an analysis of changes in the prices of the output and in the costs of production. Changes in output prices are due to changes in supply, which may be local, regional, or global (Parry et al. 1996). When changes in world food supply are taken into account, the economic analysis becomes quite complicated due to changes in trade flows and policy implications (Rosenzweig and Parry 1994).

The SILMU programme has adopted time slice scenarios (years 2020, 2050, and 2100) for the evaluation of the change in crop production

due to climate change. Mean annual temperatures will rise 1.1–6.6°C by 2100. Annual precipitation will increase, too (Carter 1996). The study by Mela et al. (1996) indicates the following effects on crop production for Finland by 2050:

- Increased yields of adapted spring cereals, improved potential for the cultivation of higher-yielding winter sown cereals.
- Increased grass yields due to the lengthening growing season.
- Increased potential for yield losses due to crop pests and diseases under climate warming.

The authors are cautious in giving any quantitative estimates of the increased yields and losses, which would be necessary for an economic analysis.

The aim of this paper is to evaluate the potential economic effects of climate change on Finnish agriculture based on the latest studies of the SILMU programme (Mela et al. 1996). Since there are no specific scenarios of the change of yields available, two examples of the economic effects on the farm level are presented. They are based on an assumed increase of the yield level and costs by 10%. These results can be easily applied for any specific scenario which may be available after further studies on yield levels. The effect of policy changes due to the altered demand and supply is considered. In addition, some earlier economic analyses are reviewed.

Economic analysis

Economic analysis has to be done at the farm level (micro level) and at the country level (macro level). At the farm level prices are given and the farmer adjusts production according to the prices of the output and inputs and the endowments available. Prices are determined by market forces and deliberate policy measures of a country (or of the European Union, EU). World market prices influence the national (or EU) prices depending on the border protection at the time

of consideration. Price changes are caused by changes in supply. Difficulties arise in estimating price changes since the policy framework is going to change within the long time horizon considered. At present the prices in Finland are determined by the Common Agricultural Policy (CAP) of the EU. Prices are regulated, and a change in the world-wide market equilibrium may not affect the internal prices of the EU at all. However, in the long run a change in the overall supply to world markets may significantly affect the prices paid to farmers.

Micro level

The economic effects of climate change comprise various factors. The change in the growing conditions affects the ability of plants to utilise the carbon dioxide in the air and the nutrients in the soil. In Finland the yield levels of crops are expected to rise as a result of the greenhouse effect. The quantity of production per hectare will increase (Hakala and Mela 1996). Changes will occur in the areas where crops can be cultivated, which alters the production structure (Carter et al. 1996). New high-yielding varieties can be introduced in Finland and the optimum level of fertilizer use may rise (Kleemola and Karvonen 1996).

Consequently, the production potential may increase in two ways: as a result of the increase in yield levels and due to introduction of the new high-yielding varieties. The pasture season is also going to be longer, and thus pastures will produce a higher yield as well.

Climate change is not likely to have any direct effects on livestock production. Milk production is not dependent on temperatures as long as there is adequate protection during the winter. Average yields do not rise as a result of higher temperatures.

Climate change will affect the costs as well. In the first place, changes occur in crop production. Because of the longer growing period temperatures are likely to be higher during harvesting. This could result in a decrease in the moisture content of harvested cereals and the costs for drying them will decrease. However, it is also

possible that the precipitation increases to the extent that moisture content will not decrease and the drying costs remain at the same level as earlier. Nevertheless, a longer growing season will lower the risks involved in cereal production, especially during harvesting. Being able to go to the fields earlier in the spring usually results in higher yields, but the time of seeding is less likely to be as significant for obtaining a good yield as it is today.

It is assumed that rising temperatures will be accompanied by more plant diseases and pests, which is going to increase the costs and slow down the rise in the yield level (Kaukoranta 1996, Carter et al. 1996).

The effect of the change in climate conditions on the costs of animal husbandry remains small. The pasture season will be longer, which may result in a reduction in fodder cost. Because of the higher temperatures, some savings may be achieved in building costs as more lightly constructed animal sheds could be adequate, but this may not be very significant (Carter et al. 1992).

Macro level

The direct macro level effects of climate change are not very significant, and for the most part they are going to result from changes in the market situation. The greenhouse effect is going to alter the supply of agricultural products. In the present situation the definition of the domestic market is a little complicated. The question is to what extent the Finnish markets operate independently, or should we always look at the issues from the viewpoint of the whole EU. From the standpoint of Finland alone, climate change is going to result in a considerable increase in supply and the price level will drop. At the EU level the changes are going to be relatively small. The effect of climate change is probably going to be positive in the northern countries of Europe, but negative in southern countries, where many scenarios indicate an increase in drought frequency and increased problems of water supply for irrigation (Harrison et al. 1995).

As cereals are easy to transport from one

country to another, the impact of the production increase in Finland on the production (and the supply) of the whole EU remains small. This means that the price change would be very small and need not be taken into account at all.

In crop production, plant breeding must be adjusted to the new situation. It is difficult to say whether this will cause additional costs. It is possible that there will be some increase in research costs, but the costs of the actual breeding activity can be considered to remain at the same level as earlier. Thus changes will mainly occur in the allocation of research funds.

World level

Changes in the agricultural production at the global level influence the world market prices and, through these, the incomes of individual farmers. The study by Rosenzweig and Parry (1994) concludes that the greenhouse effect will lead to a small decrease in global crop production with respect to the base scenario. The decrease is larger in the developing than in the developed countries (Reilly et al. 1994). This will induce a rise in the world market prices from 24 to 145%, depending on the climate scenario (Parry et al. 1996, Fischer et al. 1994).

The extent of the reaction depends mainly on how open the world markets are. The baseline assumption of the study by Parry et al. (1996) is that by 2020 there will be a 50% trade liberalisation. Going towards 2050 or 2100 the markets may be even more liberalised. This means that the price level of crops will be much higher than in 1995. The world-wide effect on prices in animal production may be smaller, since the markets are more local or regional and the price effects do not spread as effectively as in the case of cereals.

Production

Yield level

The most significant consequence of the greenhouse effect in Finland is the rise in the yield

level. There are no overall estimates of yield increases for the whole country and for all crops. Warming alone decreases yields of current cultivars in Southern Finland. Combined with CO₂ increases, yields increase in all regions, the most in Central/Northern Finland, and slightly in the south (Mela et al. 1996). Mukula (1988) and Rantanen (1988) estimated that the yields of spring wheat and barley will increase by 10–20% under a 2xCO₂ climate change scenario.

Higher temperatures make it possible to increase the use of fertilizers, which also causes the yield level to rise (Kleemola and Karvonen 1996). However, this option may not be fully utilised. The reason for this is that at present a maximum level has been set for fertilizer use, if farmers are to benefit from environmental support. It is also possible that in the future fertilizer use will be restricted even more. This means that the yield function rises, but fertilizer use is kept at an earlier level.

The adoption of new varieties may also give higher yields. Preliminary estimates for barley yields by 2050 under the SILMU "best guess" scenario of temperature, precipitation, and CO₂ change, under current N application rates gave yields increases of about 35% at Jokioinen for an adapted variety (compared with 23% for a current variety). For higher nitrogen application, the increase could be over 40% (Kleemola and Karvonen 1996).

Pasture season

The longer pasture season means higher fodder yields (Mela et al. 1996), but water stress may restrict the increase if the climate dries in summer. This change can be taken into account either in the yield level estimates or the cost calculations. Estimating the total yield from pastures is usually quite difficult and it is seldom done, even if it would be possible on the basis of e.g. livestock production. Due to variations in weather conditions, annual estimates of the yield of pastures present average figures which do not correspond to the actual amounts.

Experiments under high CO₂ and increased

temperatures equivalent to changes towards the end of the next century in Jokioinen and in Apukka, Rovaniemi suggest increases of meadow fescue yields over a whole season in the order of 20–100%, depending on the season and location (see Hakala and Mela 1996, Mela et al. 1996).

Areas

It is very difficult to estimate long-term changes in the distribution of cultivated land. In a situation of free competition the areas under cultivation would grow along with improvements in profitability and comparative advantage. Under current EU directives, the price policy, especially hectare support according to the CAP reform (Kettunen and Niemi 1994), determines the maximum areas for cultivation. It seems that over the very long term (say 50 years) increasing the cereal production in the world will become necessary due to global population growth. In this case, the growth of production potential in the north is likely to be utilised in full. However, in this connection it is not possible to take this into account, but we must start from the assumption that the areas under cereals will not grow and the growth in crop production will be based on the increase in yield level alone.

The shift of cultivation zones further to the north means, in particular, that the possibilities for the cultivation of cereals are going to improve over the whole country. Northward shifts in thermal suitability for cereals are approximately 100–150 km/°C warming or about 50 km per decade up to 2050 under the SILMU "best guess" climate scenario (Mela et al. 1996). Because the total area under cultivation is restricted within the present policy, it will only be possible to change the relative areas of the different crops so that the total area remains the same. In the longer run, however arable land area is likely to increase.

Production quantities

Changes in production concern crop production only. If the areas remain the same, crop produc-

tion will increase in proportion to the increase in the yield level. In this case the change in the value of production can be estimated as an increase in the return on crop production. Naturally it is also possible that the higher crop production would be processed into livestock products, in which case the increase in the value of the total production would be considerably larger due to the increased value added (with certain reservations, of course). On the other hand, quotas may restrict the growth in livestock production in the short term (Kettunen 1995), but in the longer term, e.g. by 2050, these restrictions, may not apply.

Economic effects

The following calculations have been done at the farm and state level. At the farm level prices are given and the farmer adjusts the production according to the prices of output and input and the endowments available. The prices are determined or influenced by the agricultural policy of a country or economic region (like the EU). Prices are also affected by the world markets depending on the closeness or openness of the country or the economic region. The effect varies according the product concerned. Cereals are easily transported around the world and, therefore, climate change will affect the world market prices of cereals. The same applies to beef and mutton prices, whereas the prices of other animal products may differ from one region to another and, thus, climate change may not affect the prices equally in all parts of the globe. (For more sophisticated methods to evaluate economic effects see Mendelsohn et al. 1994).

Assumptions

Since the estimates of the growth of the yield level and the change in the use of pesticides are uncertain, two hypothetical examples of the effects of climate change are given in Table 1. Farm

models developed at the Agricultural Economics Research Institute are applied for this purpose. The calculations are based on the assumption of a 10% growth of the yield level and a 10% increase in the costs of plant protection. These assumptions do not correspond to any scenario. However, these results can easily be applied to any specified scenario which gives the increase of yields and change in the use of pesticides. In the following calculations no changes are assumed to occur in the prices.

The change in the yield level is the most significant factor in economic calculations. Economic effects are estimated in the following assuming that a) production growth corresponds to the increase in the yield level and b) no changes occur in the use of inputs except for the increase in the use of pesticides and additional harvesting costs for the increased yield.

The base scenario is the situation in 1995. The correct way would be to determine the economic situation in the year corresponding to the 10% increase in the yield level. This is not yet possible. However, it does not affect the conclusion if prices are kept constant, as is done in this study.

Calculations

Farm calculations developed at the Agricultural Economics Research Institute were originally used for examining the adjustment to membership of the EU in 1995 (Hiiva and Alastalo, personal communication). The data are from book-keeping farms, which means that the results cannot be generalised for the whole country. However, they provide interesting information on the income development of individual farms as the prices and amount of support vary. These calculations can also be applied for examining the effects of climate change at the farm level. The figures for 1995 in Table 1 refer to averages of a group of crop and dairy farms.

In the calculations of returns, only the increase in yield is taken into account in estimating the economic effects. For dairy farms, the increase in yield is assumed to lower feeding

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Table 1. Two examples of the change in the farm income due to the 10% increase in yields.

	crop farm		dairy farm	
	1995	2050 (change)	1995	2050 (change)
Total area, ha	45.8		29.4	
Total yield, feed units	162 200	+16 220	68 700	+6870
Corresponding area, ha	35.6		20.8	
Yield, feed units per ha	4558		3304	
Price of feed unit, FIM	0.90		0.70	
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Gross return, FIM				
– crop	146 391	+14 639	317	
– animal products	226		344 772	
– subsidies	96 953		64 806	
other	8289		4787	
total	251 858	+14 639	414 682	
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Costs				
– drying	1207	+811	1505	
– plant protection ¹	11 396	+1,140	1974	+197
– purchased feed ²	170		45 399	– 4809
– other	209 088		266 299	
total	221 691	+1951	269 778	– 4612
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Farm income	30 167	+12 688	144 904	+4612
Change in %		+42		+3.2

¹ Plant protection costs +10%.

² for the dairy farm the increase in yields is assumed to lower the feeding costs.

costs, and this is valued using the price of fodder cereals (FIM 0.70/kg). In the costs the changes in plant protection and drying the additional crop (FIM 0.05/kg) are taken into account. At this stage all other factors are allowed to remain as before.

The farm model calculation shows that incomes increase (*ceteris paribus*) by about FIM 12 700 (42%) on the crop farm and FIM 4 600 on the dairy farm due to the 10% increase in the yield level (Table 1).

In the calculation no changes are assumed to occur in prices and the amounts of support. This assumption will not hold in long-term forecasts. Market forces are going to influence prices in many ways. The population grows rapidly, and it is questionable whether supply can grow at the same pace in the long run. Gradually it will become necessary to start using marginal land for production, and this will lead to a considerable

increase in the production costs. There are also other factors that are likely to cause the prices to rise, and the increase must either be paid directly by the consumers or it will lead to changes in the structure of consumption. Even though the greenhouse effect has been estimated to have a relatively small impact on agricultural production at the global level, crop prices may rise a lot (Parry et al. 1996).

Estimates concerning agriculture as a whole

A macro level study concerning the whole country can be made simply by first estimating the value of the increase in the yield level by one percentage point. The crop production of the whole country has amounted to 5 200 million–5 400 million fodder units (Kettunen 1995). The

price of barley, FIM 0.70/kg, can be used as the value of a fodder unit. Using an average total yield of 5 300 million f.u., an increase in the yield level by one percentage point increases the return by about FIM 37 million. If the production increases by 10%, the benefit is FIM 370 million.

In Finland there is altogether about 120 000 ha pasture. The quantity of fodder units this yields can roughly be estimated at 360 million f.u., and thus its value would be about FIM 288 million. If an increase in the yield is assumed to be 10%, the value of the longer pasture season could be 10%, i.e. FIM 28.8 million.

The total cost of plant protection has amounted to about FIM 300 million (Kettunen 1995). This can be expected to rise by FIM 30–60 million. The harvesting cost of the increased yield is about FIM 0.05/kg, i.e. about FIM 7.5 million for 150 million kg. The increase in costs is only 5% of the increase in returns. The calculations of returns include a large margin of error. The increase in costs remains quite small.

The total effect of a 10% increase in the yield level is about FIM 360 million, i.e. 6% of the total farm income of FIM 6 000 million (see also Kettunen 1988).

Other estimates

Kuoppamäki (1995) has estimated the effects of climate change on the whole national economy, and his study also includes a short chapter on agriculture. According to his study, by the year 2050 the benefit to agriculture will be FIM 1.255 billion, and in relation to the annual agricultural income of FIM 6 billion the increase is 20%. This is based on an increase of the yield level by 40%, growth of horticultural production by 50%, and a decrease of 10% in the costs of animal fodder as a result of the longer pasture season. The estimate is in line (a little smaller) with the estimate above.

The second method for estimating the benefits to agriculture presented by Kuoppamäki (1995) is also interesting. It is based on the price of land, which he assumes to increase along with

rising temperatures. On the basis of a function estimated from a cross section of data over Finland: land price = $f(\text{temperature})$. Kuoppamäki (1995) arrives at an estimate according to which the benefit to agriculture is FIM 2.2 billion. When the fertilizer effect of CO₂ is taken into account a further multiplication factor of 1.2 is applied and the total benefit is FIM 2.7 billion.

The methods presented by Kuoppamäki can be criticised for the part concerning the dependence between the price of land and temperature. It might be more appropriate to estimate the dependence between the price of land and yield level. Even if the temperatures rise in the northern parts of the country, the production capacity of the land does not necessarily increase in the same proportion.

Discussion

In the assessment of the economic effects of climate change, changes at the farm level, i.e. in returns and costs, have to be taken into consideration. Changes in returns are mainly caused by changes in the yield level, but yield quality may also improve if the growing season is longer and the temperatures higher. As the temperatures rise in Finland, the cultivation zones of different crops may move further to the north. New breeds or even new crops may increase the returns.

Costs are influenced by various factors. Harvesting conditions may improve as the temperatures are higher and the growing season is longer, which reduces costs. However, an increasing need for pest control results in higher costs. An increase in productivity increases the price of land, at least in principle, which also leads to cost increases.

In a free economy, increase in the supply results in a decrease in the price level. If we focus on Finland only, as distinct from other countries, it can be assumed that the price level will not change, as prices are determined for the whole

EU area. If the greenhouse effect is looked at from the global perspective, the assumption is not true. The field crop production of the whole world is going to change, which inevitably affects world market prices. The effect on national agricultural production depends on the border controls used. Changes in world market prices are likely to influence the national economy through national support policies.

It is very difficult to estimate the long-term development of cultivated area. With free competition the area under cultivation increases as profitability and comparative advantage improve. Under present EU pricing policy, hectare support determines the maximum area under cultivation. In the very long run (e.g. by 2050) the need for increasing cereal production in the world seems obvious due to population growth. In this situation the growing potential of the northern areas is likely to be utilised in full.

Various extensive studies have indicated that

the greenhouse effect increases the crop potential in Finland. The benefit is visible both as an increase in crop production and as lower costs in animal husbandry. From the economic point of view the increase in yield level is highly significant. It is almost pure income, because the increase in the costs remains quite small. A 10% increase in the yield level raises the farm income by about 6%. In particular, the benefit will be important for crop producers.

Because agriculture is supported in many ways either directly (direct income support) or indirectly (by tariffs or subsidies), a rise in the income level may be offset by lowering the support. Consequently, farmers may not benefit from an increase in yield level, but the benefit will go to the state economy. However, an increase in yields resulting from rising temperatures is advantageous to the national economy, regardless of whether the benefit goes to the farmers or to the state.

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SELOSTUS

Ilmastonmuutoksen taloudelliset vaikutukset suomalaiseen maatalouteen

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Maatalouden taloudellinen tutkimuslaitos

Kun arvioidaan ilmastonmuutoksen taloudellisia vaikutuksia Suomen maataloudelle, on otettava huomioon sekä kustannusten että tulojen muutokset. Tuloihin vaikuttavat pääasiassa satotason muutokset, mutta kustannuksiin useat eri tekijät. Korjuuolot saattavat muuttua suotuisemmiksi keskilämpötilan noustessa, mikä pienentää kustannuksia. Toisaalta olosuhteet muuttuvat otollisemmiksi myös kasvitaudeille ja tuhoeläimille, mikä puolestaan aiheuttaa lisäkustannuksia. Monet tutkimukset ovat osoittaneet, että lämpötilan kohoaminen ja ilman hiilidioksidipitoisuuden nousu lisäävät satopotentiaalia Suomessa. Taloudel-

liselta kannalta satotason nousu on hyvin merkittävä seikka, sillä samanaikaisesti kustannukset kohoavat melko vähän: 10 % satotason nousu lisää tilan tuloja 6 %. Koska maataloutta tuetaan monella tavoin joko suorasti tai epäsuorasti, tulojen nousu voi jäädä merkityksettömäksi tukien vähetessä. Tällöin satotason noususta aiheutuva lisätulo ei hyödyttäisi viljelijää, vaan valtiontaloutta. Kohonneesta lämpötilasta aiheutuva satotason nousu on kuitenkin edullista koko kansantalouden kannalta riippumatta siitä, saako hyödyn viljelijä vai valtio.