The idea of environmental welfare economics

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Abstract

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This study focuses on systematic alterations of the production factor nature in the course of time. At issue are the repercussions of the process of depletion of natural stocks and the consequences of the pollution process on the one hand, and the implications of the various forms of technological development on the other.

The model concerned contains three categories of production factor: land, raw materials and labour. The derived factor capital is not mentioned explicitly. The static basic model used can be characterized as 'dualistic', in the sense that prices as well as quantities are endogenous. The parameters of the model in its static form are: the total quantities of production factors applied, the figures characterizing the faculties of the production factors represented, and the figures determining the welfare function. Some of these parameters are variables in the 'dynamicized' model.

It appears to be possible to extend the model so that multifunctional use of land is reflected. It also appears to be possible to formulate the basic model as a location model, in accordance with the Thünen tradition.

Progress in environmental technology is considered to be factor-sparing. In this concept two components are distinguished. The first is the factor-saving element, in the Hicksian sense. The second component is connected with the change of the factor share in the income, and is determined by substitution elasticities in the sphere of production.

An important aspect is the phenomenon of eliminating the unpaid function of the factor nature. The function concerned is the contribution of 'traditional' agriculture and forestry to the preservation of nature. It is apparent that an internalizing of this function is socially constructive.

From an environmental point of view, three policy scenarios must be designed, directed to the restructuring of industry, the stimulation of environmental technology, and the adaption of the institutional framework of production and consumption. The institutional alterations must be such that labour is comparatively cheap, in order to minimize the substitution of raw materials for labour.

Two types of preservation policy can be distinguished: a complementary policy and an interventionist policy. The first is included in the rational considerations about the size of government production. The latter is necessary to bring goals in private production into line with social goals.

depletion / externalities / factor-saving / substitutability / technology / functions of nature / location / preservation

CONTENTS

PREFACE

This essay 'The idea of environmental welfare economics' is based on several sets of lecture notes. Since these lectures all rested on the same basic ideas, they can be included in this compound treatise.

The principles of the model discussed were laid down in 'Nature-sparing technology in dynamic welfare theory: The role of factor substitution', presented at the European Congress of the Regional Science Association, Athens, August 1987. This model was elaborated in terms of the various functions of land and, under the title 'Degeneration and regeneration of land in welfare economics: The hidden function of agriculture and forestry' this study was presented to the congress on Environmental Policy in a Market Economy, Wageningen, September 1987. The aspect of environmental technology policy was raised in a preparatory study for this essay, discussed at the 'Ecozoekdag', a yearly meeting of Dutch economic researchers, held in Amsterdam in May 1987. The last subject discussed in this compound essay is taken from the lecture 'The consideration of preservation of nature in public choice', given at Limburg State University, Maastricht, December 1986.

The inspiration to elaborate the ideas presented in these various studies came from discussions held with Prof. J.G. Backhaus, Limburg State University, Prof. H. Folmer, Wageningen Agricultural University, Prof. J. Muysken, Limburg State University and Emeritus Prof. A.N. Rugina, Northeastern University, Boston.

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The author

1. INTRODUCTION

The idea of environmental welfare economics has various facets. Those that are considered to be essential will be exposed in this essay. Special attention is given to the structure of the model elaborated, the function of agriculture and forestry in preserving nature, the politics of environmental technology, and, finally, the question of public choice with regard to the quality of the environment of life.

Anghel Rugina (1986,p.8) pleads for "a simultaneous equilibrium versus disequilibrium approach". In certain sense, this study fulfils this requirement, because the analysis is placed between two poles: disequilibrium in reality and equilibrium in the sphere of basic theory. Further, the idea of H.C. Binswanger (1972,p.266) is adapted, that a dynamic economic model must also reflect the interaction with nature.

The model concerned contains three categories of production factor: land, raw materials and labour. The derived factor capital is not mentioned explicitly. The static basic model used can be characterized as 'dualistic', in the sense that prices as well as quantities are endogenous. The parameters of the model in its static form are: the total quantities of production factors applied, the figures characterizing the faculties of the production factors represented, and the figures determining the welfare function. Some of these parameters are variables in the 'dynamicized' model.

The dynamics of the model are such that it reflects the degeneration of the production capacity of nature, under influence of production, as well as its regeneration through the development of environmental technology. Given the preferences of society, in the dynamic model the capacity of land is determined by the rate of exploitation of natural stocks and by the properties of technology.

The role of factor substitution

Many forms of nature-sparing technology can be imagined, each emphasizing different techniques. Here, special attention must be paid to the role of factor substitution.

The pressure of production on the faculties of land is effectuated through the accumulation of active waste in nature. It will be demonstrated that the exploitation rate of natural stocks determines the picture of development. In this connection the values of emission coefficients are also important. Environmental technological progress is considered to be 'factor-sparing'. In the model elaborated, social welfare is conceived in the Pigovian way. As far as environmental technology is concerned, welfare is determined by: the degrees of capacity of the various production factors; the production elasticities of these factors, under the condition that the substitution elasticities are unity; the substitution elasticities concerned; and the emission coefficients. These figures must be examined in relation to the rates of exploitation of natural stocks.

The hidden function of agriculture

The industrialization of the economy involves production becoming less and less integrated in ecological processes. In the agrarian sector as well, industrialization is at the expense of the 'ecological function' that land fulfils in traditional agriculture and forestry. The social valuation of this hidden function can be reflected in the model. As a result, the optimal utilization of land alters.

To avoid land being applied in industrial agrarian production when, in society's eyes, it is unsuitable for it, a subsidy could be granted to farmers and foresters. The size of this subsidy should be commensurate with the positive effect of the land being administered.

The politics of environmental technology

What kinds of technological development can be considered as technological progress from an environmental point of view? It will be shown that '*laissez faire*' does not automatically result in this kind of 'progress'. It will also be revealed that, on the other hand, the market mechanism is an indispensable element in environmental technology policy.

The institutional framework should have the following properties. The price system should properly express the scarcity ratios of production factors. Further, welfare must be as high as possible at comparatively low wages, to prevent needless substitution of labour for nature. Finally, the institutional structure must be such that preferences are primarily oriented on 'services' and less on 'material goods'.

Three types of technology scenarios will be distinguished. In the short run a plan for the restructuring of industry is relevant. In the intermediate term a plan to stimulate environmental technology is opportune. In the long run a plan to adapt the institutional framework has to be implemented.

Public choice and the preservation of nature

To discuss the problem of the preservation of the environment of life in public choice, two indices are defined: a production index of typically economic goods, and an index of the quality of the environment. On the basis of these concepts the production of 'environmental goods' by the government, and, further, the interventionist government policy are analysed. Finally, the welfare theory scheme of thought is fitted into a systems theory framework.

2. THE STATIC BASIC MODEL

This study focuses on systematic alterations of the production factor nature in the course of time. At issue are the repercussions of the process of depletion of natural stocks and the consequences of the pollution process on the one hand, and the implications of the various forms of technological development on the other. This picture will be analysed in terms of welfare economics, à la Pigou. First, the latter way of thinking will be oriented on static models of general equilibrium. To reflect the developments mentioned, the model is 'dynamicized'. Some parameters of the basic model are variables in the dynamic model.

The principle of the 'dualistic' model

In economics, the principle of duality of linear models is applied to systems in which either prices function as variables and quantities of goods as parameters, or quantities function as variables and prices as parameters. The model presented here also contains the additive functions of the above models: however, it is not linear. To solve the model, prices and quantities must be determined simultaneously, by an iterative procedure: hence the indication 'dualistic'.

In its most elementary form, the static model is as follows. The equations are formulated in such a way that the model, as well as the subsequent models, can be applied to a greater number of products and production factors. The elementary model contains two products and two production factors.

To express the welfare (U) in units of money, the sum of the 'welfare elasticities' (E_k^U) has to be unity, as indicated for (E.4). To let the value of the products fall to the production factors, without specific problems, in any production process the sum of the production elasticities ($E_{x_{ki}}$) has to be unity, as indicated for (E.5).

In the model the following considerations are expressed. The shares (E_k^U) of the products in the social budget, as well as the factor shares ($E_{x_{ki}}$) in the values of the products, are constant. The above model has the properties of the Cobb-Douglas production function. The production function is more an aspect than an element of the model. The function is 'homothetic', in the sense that is abstracted from the possibility that "the level of output and the degree of technical progress will explicitly have effects on factor combinations"; see Sato (1977,p.559). Note too, that the phenomenon of 'overhead labour' is not taken into account; see Muyskens (1984,p.440).

elementary model		number of equations
(E.1)	$U = \sum_{k=1}^{2} Y_k$	1
(E.2)	$Y_k = p_k \, y_k$	2
(E.3)	$Y_k = v_1 \, x_{k1} + v_2 \, x_{k2} + v_3 \, x_{k3}$	2
(E.4)	$p_k = E_k^U \, \frac{U}{y} \qquad (\sum_{k=1}^{2} = 1)$	2
(E.5)	$v_i = E_{ki}^y \, \frac{y}{x_{ki}} \qquad (\sum_{i=1}^{3} = 1)$	6
(E.6)	$\sum_{k=1}^{2} = \hat{x}_i$	3
		16

Variables:

U :	social welfare	1
y_k:	quantity of product k	2
p_k:	price of product k	2
Y_k:	value of product k	2
x_{ki}:	quantity of factor i in production process k	6
v_i:	price of factor i	3
		16

Parameters:

E_k^U :	welfare elasticity of product k
E_k^y :	production elasticity of factor i in process k
$\hat{x}_i$:	total quantity of factor i

The substitution aspect

In the elementary model, substitution elasticities are minus unity, in the welfare sphere as well as in the production sphere. The following system of equations, indicated as the basic model, reflects substitutability of products and factors in a nuanced way. This aspect is formulated by the equation:

$$\frac{x_r}{x_s} = \mu \left(\frac{v_r}{v_s} \right)^{\sigma_{rs}}$$

In this function σ_{rs} expresses the substitution elasticity between the products r and s and the production factors r and s; μ is a parameter. Equations (B.6) and (B.7) are based on this general formula. Here, the E variables express the part of the aggregate income that is spent on the product concerned, and the part of the product value that falls to the production factor concerned. E^{U} and E^{y}, although treated as parameters, are written as $\hat{E}^{U}$ and $\hat{E}^{y}$. In the model, the parameter μ has the value $\hat{E}_r/\hat{E}_s$. In order to reach acceptable conclusions:

for (B.4): $\sum_k E_k^U = 1$, and for (B.5): $\sum_i E_{ki} = 1$

In the model the following considerations are expressed. The share of the product in the social budget and the factor share in the value of the product are reflected in the variables E in the functions (B.4) and (B.5). These quantities are indicated as 'effectivities'. If the value of the substitution elasticities σ is minus unity, the effectivities are parameters ($E = \hat{E}$). In that case these figures reflect welfare elasticities and production elasticities, respectively.

The model contains three products and three production factors. With a smaller number the model is under-determined; with a greater number it is over-determined. If it is necessary to reflect a greater number of products and production factors than the three included in the above model, a solution is to group the products and factors in sets of products and in partial production processes, in such a way that the 'three-by-three formula' remains.

In principle, the idea of the 'translog' production function offers a way out of the restriction mentioned. Lee (1983,p.161) presents an adaptation of the translog function to the manyfactors case; see also H.P. Binswanger (1974a,p.965). When the model is modified in this way, however, it becomes less surveyable.

The above type of model, in which the substitution is expressed in a nuanced way, is rather complicated, and as a result, the particular properties of specific variants of the model may be obscured. Therefore, in the continuation of this *basic model*

		number of equations
(B.1) $U = \sum_{k=1}^{3} Y_k$		1
(B.2) $Y_k = p_k \, y_k$		3
(B.3) $Y_k = v_1 \, x_{k1} + v_2 \, x_{k2} + v_3 \, x_{k3}$		3
(B.4) $p_k = E^U_k \, \frac{U}{y_k}$		3
(B.5) $v_i = E^y_{ki} \, \frac{y_k}{x_{ki}}$		9
(B.6) $\frac{E^U_k}{E^U_m} = \frac{\hat{E}^U_k}{\hat{E}^U_m} \left(\frac{p_k}{p_m} \right)^{\sigma^u_{km} + 1}$	(k=1,2,3) (m=1,2,3) (k≠m)	3
(B.7) $\frac{E^y_{ki}}{E^y_{kj}} = \frac{\hat{E}^y_{ki}}{\hat{E}^y_{kj}} \left(\frac{v_i}{v_j} \right)^{\sigma_{kij} + 1}$	(k=1,2,3) (i=1,2,3) (j=1,2,3) (i≠j)	9
(B.8) $\sum_{k=1}^{3} x_{ki} = \hat{x}_i$		3
		34

study the equations of the type (B.6) and (B.7) have not been inserted in the models. The effects in the sphere of substitution will be described in the assessment of these models.

Variables:		number:
U:	social welfare	1
y_k:	quantity of product k	3
p_k:	price of product k	3
Y_k:	value of product k	3
x_{ki}:	quantity of factor i in production process k	9
v_i:	price of factor i	3
E^U_k:	welfare 'effectivity' of product k	3
E^y_{ki}:	production 'effectivity' of factor i in process k	9
		34

Parameters:

σ^u_{km}:	substitution elasticity in the welfare sphere of products k and m
σ_{kij}:	substitution elasticity of factors i and j in process k
$\hat{E}^U_k$:	welfare effectivity of product k, if substitution elasticities are -1
$\hat{E}^y_{ki}$:	production effectivity of factor i in process k, if substitution elasticities are -1
$\hat{x}_i$:	total quantity of factor i

For the analysis, the following facet of the model must be examined further. Formula (B.5) can be written as:

$$\text{(B.5a)} \quad E^{y}_{ki} \frac{y_k}{v_i} = x_{ki}$$

or, alternatively as:

$$\text{(B.5b)} \quad E^{y}_{ki} \frac{y_k}{v_i} = e^{-\varepsilon_{ki}} x_{ki}$$

In this form, the symbol e is the base of the natural logarithm. Note too, that ε can have a positive as well as a negative value. If its value is zero, (B.5b) is identical to (B.5a). If, *ceteris paribus*, the value of ε increases, the effect is comparable with an increase in the available quantity of the production factor concerned.

In this study, attention is directed to the productivity of nature in its various qualities. Obviously, the factor labour must also be brought into the analysis. To keep the model as simple as possible, the factor capital is not explicitly mentioned. In principle this is possible because capital is a production factor, 'derived' from the original factors nature and labour. In the model, the capital is liquid, in a certain sense. Thus the production function of the model refers directly to the original factors of production. Schefold (1976,p.815), elaborating the various forms of technological development, pays particular attention to the composition of capital. He states: "The direct counterpart to the pure saving of labour is saving of raw materials."

Structure of the basic model

The basic model is structured in accordance with the 'three-by- three formula', presented above. Three categories of product are distinguished: agrarian products (A), industrial products (M), and services (S). Also three categories of production factor are presented: land (X), raw materials (Q), and labour (L). This is outlined in Figure 1.

agrarian products (A)			
industrial products (M)			
services (S)			
	land (X)	raw materials (Q)	labour (L)

Figure 1. Structure of the static model

This scheme is elaborated further in the same way, by forming sub-categories. The entire scheme is outlined in Figure 2. In the following, the system of equations is worked out in accordance with this scheme.

		X_1 barren land	X_2 land of little productivity	X_3 very useful land	Q_1 raw materials of latent scarcity	Q_2 somewhat scarce raw materials	Q_3 very scarce raw materials	L labour
preservation of nature	A_1							
traditional agriculture	A_2							
industrial agriculture	A_3							
handicrafts	M_1							
engineering	M_2							
mass production	M_3							
services	S							

Figure 2. Detailed structure of the static model

structured model

			number of equations
(S.1)	$U = A\,p_A + M\,p_M + S\,p_S$		1
(S.2)	$A\,p_A = A_1\,p_{A1} + A_2\,p_{A2} + A_3\,p_{A3}$		1
(S.3)	$M\,p_M = M_1\,p_{M1} + M_2\,p_{M2} + M_3\,p_{M3}$		1
(S.4)	$A_i\,p_{Ai} = \sum_{r=1}^{3} v_r\,X_{Air} + \sum_{s=1}^{3} w_s\,Q_{Ais} + z\,L_{Ai}$		3
(S.5)	$M_j\,p_{Mj} = \sum_{r=1}^{3} v_r\,X_{Mjr} + \sum_{s=1}^{3} w_s\,Q_{Mjs} + z\,L_{Mj}$		3
(S.6)	$S\,p_S = \sum_{r=1}^{3} v_r\,X_{Sr} + \sum_{s=1}^{3} w_s\,Q_{Ss} + z\,L_S$		1
(S.7)	$p_A = E^U_A \frac{U}{A} \qquad p_M = E^U_M \frac{U}{M} \qquad p_S = E^U_S \frac{U}{S}$		3
(S.8)	$p_{Ai} = E^A_m \frac{A}{A_m} \qquad p_{Mj} = E^M_n \frac{M}{M_n}$	(m=1,2,3) (n=1,2,3)	6
(S.9)	$v_r = E^{Ai}_{Xir} \frac{A_i}{X_{Air}} \qquad w_s = E^{Ai}_{Qis} \frac{A_i}{Q_{Ais}} \qquad z = E^{Ai}_{Li} \frac{A_i}{L_{Ai}}$	(i=1,2,3) (r=1,2,3) (s=1,2,3)	21
(S.10)	$v_r = E^{Mj}_{Xjr} \frac{M_j}{X_{Mjr}} \qquad w_s = E^{Mj}_{Qjs} \frac{M_j}{Q_{Mjs}} \qquad z = E^{Mj}_{Lj} \frac{M_j}{L_{Mj}}$	(j=1,2,3) (r=1,2,3) (s=1,2,3)	21
(S.11)	$v_r = E^S_{Xr} \frac{S}{X_{Sr}} \qquad w_s = E^S_{Qs} \frac{S}{Q_{Ss}} \qquad z = E^S_L \frac{S}{L_s}$	(r=1,2,3) (s=1,2,3)	7
(S.12)	$\sum_{i=1}^{3} X_{Air} + \sum_{j=1}^{3} X_{Mjr} + X_{Sr} = \hat{X}_r$		3
(S.13)	$\sum_{i=1}^{3} Q_{Ais} + \sum_{j=1}^{3} Q_{Mjs} + Q_{Ss} = \hat{Q}_s$		3
(S.14)	$\sum_{i=1}^{3} L_{Ai} + \sum_{j=1}^{3} L_{Mj} + L_S = \hat{L}$		1
			75

Variables:

U	: social welfare	1
A	: quantity index of the agrarian production	1
p_A	: price index of agrarian products	1
M	: quantity index of the industrial production	1
p_M	: price index of industrial products	1
S	: quantity index of the production of services	1
p_S	: price index of services	1
A_i	: quantity of agrarian product i	3
p_{Ai}	: price of agrarian product i	3
M_j	: quantity of industrial product j	3
p_{Mj}	: price of industrial product j	3
X_{Air}	: quantity of factor r (land) in the agrarian production process i	9
X_{Mjr}	: quantity of factor r in the industrial process j	9
X_{Sr}	: quantity of factor r in the production of services	3
v_r	: price of factor r (land)	3
Q_{Ais}	: quantity of factor s (raw materials) in the agrarian process i	9
Q_{Mjs}	: quantity of factor s in industrial process j	9
Q_{Ss}	: quantity of factor s in the production of services	3
w_s	: price of factor s (raw materials)	3
L_{Ai}	: quantity of labour in agrarian process i	3
L_{Mj}	: quantity of labour in industrial process j	3
L_S	: quantity of labour in the production of services	1
z	: price of production factor labour	1
		75

Parameters:

E : effectivities (3+6+21+21+7=58)

$\hat{X}_r$, $\hat{Q}_s$ and $\hat{L}$: total available quantities of production factors (3+3+1)

3. EXTENSIONS OF THE STATIC MODEL

The subject of the functionality of land requires that the basic model be extended in two directions. First, the model must reflect that land sometimes performs various functions simultaneously. Further, the impact of transportation costs on the spatial structure of economic activity must be represented.

Multifunctional use of land

A special feature of the static model deserves explanation. Hueting (1974) opines that nature fulfils various functions. He points out that a certain function is sometimes performed at the cost of performing another function. In this case, Hueting speaks of 'competition of functions'. It will be demonstrated how the competition of functions can be reflected in the model.

In the context of this study the following form of competition of functions is of interest. Preservation of nature contributes to welfare. In the model, the production function concerned is located in the agrarian sector. There is a good reason for this. Many agrarian areas are of importance for the preservation of nature, and any extension of industrialized agriculture in these areas often proceeds at the expense of this function of land. Of course, the production of 'nature goods' as well as of agrarian products in general, is also under the pressure of certain forms of industrial production.

The inclusion in the scheme of thought of the multifunctional use of land will be demonstrated in two models. In these simplified models, the land can fulfil two and three functions respectively. The analysis can be extended to more simultaneous functions.

It is assumed that, in principle, any form of utilization of land can appear in any production process. However, it is not assumed that all variables concerned have a value greater than zero; suffice it to state that these variables are not negative. Further, it is assumed that the value of land is not influenced by direct government regulations on the use of land. Thus, the value of land of a certain quality is equal in monofunctional and in multifunctional use. The model contains land of various qualities and, further, various raw materials. The abstraction proceeds from other production factors.

Characteristic of the latter model is the great number of 'effectivities' that could be relevant. The question arises whether the above model can be converted into a model with substitution elasticities as parameters, instead of the welfare and production elasticities. The answer is that this is not possible a priori. However, a solution might be found in an abstraction from reality that succeeds in approximating a presentation on the basis of the 'three-by-three formula'.

The model is based on the assumption that the provision with production factors is such, that a situation of full competition is approximated with regard to separate functions of land.

bifunctional model

			number of equations
(D.1)	$U = A_1 p_1 + A_2 p_2$		1
(D.2)	$A_k p_k = \sum_{r=1}^{2} \underset{(f)}{v_{1r}} \underset{(f)}{X_{1kr}} + \sum_{r=1}^{2} \sum_{a=1}^{2} \underset{(f)}{v_{2ar}} \underset{(f)}{X_{2akr}}$	(k=1,2)	2
(D.3)	$p_k = E_k^U \frac{U}{A_k}$		2
(D.4)	$\underset{(f)}{v_{1r}} = \underset{(f)}{E_{1kr}} \frac{A_k}{X_{1kr}}$	(r=1,2)	4
(D.5)	$\underset{(f)}{v_{2ar}} = \underset{(f)}{E_{2akr}} \frac{A_k}{X_{2akr}}$	(a=1,2)	8
(D.6)	$v_{2r} = \sum_{a=1}^{2} v_{2ar}$		2
(D.7)	$v_{1r} = v_{2r}$		2
(D.8)	$\sum_{k=1}^{2} \underset{(f)}{X_{1kr}} = \alpha_r X_r$		2
(D.9)	$\sum_{k=1}^{2} \underset{(fa)}{X_{21kr}} = \sum_{k=1}^{2} \underset{(fa)}{X_{22kr}} = (1-\alpha_r) \hat{X}_r$		4
			27

Variables of the bifunctional model:

U	: social welfare	1
A_k	: quantity of product k (k=1,2)	2
p_k	: price of product k	2
X_{1kr}	: area of land of quality r (r=1,2) in single use, in production process k	4
X_{2akr}	: area of land of quality r in twofold use, with function a (a=1,2), in process k	8
v_{2ar}	: value of land of quality r in twofold use, as far as accountable to function a	4
v_{fr}	: total value of land of quality r in f-fold use	4
α_r	: the proportion of land of quality r in single use	2
		27

Parameters:

E : effectivities

$\hat{X}_r$: total area of land of quality r *trifunctional model* — number of equations

	Equation	number of equations
(T.1)	$U = \sum_{k=1}^{m} A_k \, p_k$	1
(T.2)	$A_k \, p_k = \sum_{r=1}^{n} v_{1r} X_{1kr} + \sum_{r=1}^{n} \sum_{a=1}^{2} v_{2ar} X_{2akr} + \sum_{r=1}^{n} \sum_{b=1}^{3} v_{3br} X_{3bkr}$	m
(T.3)	$p_k = E_k^U \dfrac{U}{A_k}$	m
(T.4)	$v_{1r} = \underset{(f)}{E_{1kr}} \dfrac{A_k}{X_{1kr}}$	m n
(T.5)	$v_{2r} = \underset{(fa)}{E_{21kr}} \dfrac{A_k}{X_{21kr}} + \underset{(fa)}{E_{22kr}} \dfrac{A_k}{X_{22kr}}$	m n
(T.6)	$v_{3r} = \underset{(fb)}{E_{31kr}} \dfrac{A_k}{X_{31kr}} + \underset{(fb)}{E_{32kr}} \dfrac{A_k}{X_{32kr}} + \underset{(fb)}{E_{33kr}} \dfrac{A_k}{X_{33kr}}$	m n
(T.7)	$\sum_{k=1}^{m} X_{1kr} = \alpha_r \hat{X}_r$	n
(T.8)	$\sum_{k=1}^{m} \underset{(fa)}{X_{21kr}} = \sum_{k=1}^{m} \underset{(fa)}{X_{22kr}} = \beta_r (1-\alpha_r) \hat{X}_r$	2 n
(T.9)	$\sum_{k=1}^{m} \underset{(fb)}{X_{31kr}} = \sum_{k=1}^{m} \underset{(fb)}{X_{32kr}} = \sum_{k=1}^{m} \underset{(fb)}{X_{33kr}} = (1-\alpha_r)(1-\beta_r) \hat{X}_r$	3 n
(T.10)	$v_{1r} = v_{2r} = v_{3r}$	2 n
		1+2m+8n+3mn

Variables of the trifunctional model:

U :	social welfare	1
A_k:	quantity of product k (k=1,2,...m)	m
p_k:	price of product k	m
X_{1kr} :	area of land of quality r (r=1,2,...n) in single use, in production process k	m n
X_{2akr} :	area of land of quality r in twofold use, with function a (a=1,2), in process k	2 m n
X_{3bkr} :	area of land of quality r in triple use, with function b (b=1,2,3), in process k	3 m n
v_{2ar} :	value of land of quality r in twofold use, as far as accountable to function a	2 n
v_{3br} :	value of land of quality r in triple use, as far as accountable to function b	3 n
v_{fr} :	total value of land of quality r in f-fold use	3 n
α_r :	the proportion of land of quality r in single use	n
β_r :	the proportion of the land of quality r, of the area that is *not* in single use, that is in twofold use	n
	.	1+2m+10n+6mn

Parameters:

E : effectivities

$\hat{X}_r$: total area of land of quality r

Location theory

Both environment and technical problems are subjected to regional economic study. Industrialization is an important cause of degeneration of nature, and the location of industry plays an important part in this. On the other hand, industry offers the most opportunities to improve the situation, by adopting technologies aimed at the conservation of nature. In this connection, the degree of concentration of industrial production in certain areas is important.

Johann Heinrich von Thünen (1850) is credited with including the spatial dimension in economic theory. In Thünen's concept, however, production is principally agrarian, and moreover, his ideas are restricted by the Ricardian theory of rent. Wilhelm Launhardt (1885) presented an elementary location theory in mathematical terms. Two decades later, Alfred Weber (1909) introduced a more general location theory, which, like the above theories, is principally based on transport costs. Weber's theory includes industrial production. Further, it not only takes into account the transportation costs from the place of production to the buyer, but also the transportation costs of raw materials. By so doing, the loss of weight of these materials in the production process is taken into account.

Harold Hotelling (1929) is another leading author in this tradition. In the words of Walter Isard (1956,p.160), Hotelling was the first to allow price and location to vary simultaneously. Below, it will be demonstrated that transportation costs can be inserted in the model elaborated in this study.

The basic model presented earlier is converted into a location model of production along the following lines. The whole area is subdivided into equal-sized square or octagonal regions. The centre of each region is indicated by the co-ordinates z and d. The distances between the regions are measured from centre to centre. Consumption is assumed to be located in region Roo. In relation to the exploitation of raw materials, the regions are indicated as R_{zd}.

To facilitate the analysis, some simplifying assumptions are made. The assumption concerning the place of consumption has already been mentioned. Others are:

- the raw material used in a particular production process in a certain region originates from one distinct region, yet raw materials used in different production processes in a certain region, can be bought in different regions;
- price differences reflect uniform transport costs;
- all prices are per kilogram;
- the cost of transport is reckoned in one money unit per kilogram per kilometre.

The welfare function and the production functions of the above model are of the type of the previous models. The location model is so formulated that substitution elasticities are unity. To reflect other degrees of substitution, the model has to be modified as mentioned previously.

The variables of the model are determined with different sets of values of ζ and δ, which, however, result in different values for the social welfare U. The problem is to find the set of values that maximizes welfare.

Location model — number of equations

(L.1) $$U = \sum_k p_k\, y_k \qquad 1$$

(L.2) $$y_k = \sum_\zeta \sum_\delta y_{k\zeta\delta} \qquad m$$

(L.3) $$p_{k\zeta\delta}\, y_{k\zeta\delta} = \sum_r v_{r\zeta\delta}\, x_{kr\zeta\delta} + \sum_s w_{s\zeta\delta}\, q_{ks\zeta\delta/\hat{\zeta}\hat{\delta}} \qquad m\ z\ d$$

(L.4) $$p_k = E_k^U \frac{U}{y_k} \qquad m$$

(L.5) $$v_{r\zeta\delta} = E_{kr\zeta\delta}^y \frac{y_{k\zeta\delta}}{x_{kr\zeta\delta}} \qquad m\ n\ z\ d$$

(L.6) $$w_{s\zeta\delta} = E_{ks\zeta\delta}^y \frac{y_{k\zeta\delta}}{q_{ks\zeta\delta/\hat{\zeta}\hat{\delta}}} \qquad m\ h\ z\ d$$

(L.7) $$p_{k\zeta\delta} = p_k - |R_{\zeta\delta} \overrightarrow{\ } R_{00}| \qquad m\ z\ d$$

(L.8) $$w_{s\zeta\delta} = w_{s\hat{\zeta}\hat{\delta}} + |R_{\hat{\zeta}\hat{\delta}} \overrightarrow{\ } R_{\zeta\delta}| \qquad h\ z\ d$$

(L.9) $$\sum_k x_{kr\zeta\delta} = \hat{x}_{r\zeta\delta} \quad \text{and} \quad \sum_k \sum_\zeta \sum_\delta q_{ks\zeta\delta/\hat{\zeta}\hat{\delta}} = \hat{q}_{s\hat{\zeta}\hat{\delta}} \qquad (n+h)\ z\ d$$

Variables:

$(\zeta=1,2,\ldots z)$
$(\delta=1,2,\ldots d)$
$(\hat{\zeta}=1,2,\ldots z)$
$(\hat{\delta}=1,2,\ldots d)$
$(r=1,2,\ldots m)$
$(s=1,2,\ldots h)$

U : social welfare

y_k : quantity of product k

p_k : price of product k in region R_{00}

$y_{k\zeta\delta}$: quantity of product k produced in region $R_{\zeta\delta}$

$p_{k\zeta\delta}$: price of product k in region $R_{\zeta\delta}$

$x_{kr\zeta\delta}$: area of land of quality r, used in process k in region $R_{\zeta\delta}$

$v_{r\zeta\delta}$: value of land of quality r in region $R_{\zeta\delta}$

$q_{ks\zeta\delta/\hat{\zeta}\hat{\delta}}$: quantity of raw material s originating from $R_{\hat{\zeta}\hat{\delta}}$, used in process k in $R_{\zeta\delta}$

$w_{s\zeta\delta}$: price of raw material s in $R_{\zeta\delta}$, inclusive freight

$w_{s\hat{\zeta}\hat{\delta}}$: price of raw material s in exploitation region $R_{\hat{\zeta}\hat{\delta}}$

Parameters:

$\hat{x}_{r\zeta\delta}$: area of land of quality r in region $R_{\zeta\delta}$

$\hat{q}_{s\hat{\zeta}\hat{\delta}}$: available quantity of raw material s, gained in region $R_{\hat{\zeta}\hat{\delta}}$

$|\overrightarrow{R_{\zeta\delta} R_{00}}|$: z×d×m matrix of distances between the production regions $R_{\zeta\delta}$ and the consumption region R_{00}, per product; in the solution process, all elements of the matrix that do not correspond with the relevant values of ζ, δ and k, are considered to be zero; the remaining element $>$ zero

$|\overrightarrow{R_{\zeta\delta} R_{\hat{\zeta}\hat{\delta}}}|$: z×d×z×d×h matrix of distances between the production regions $R_{\zeta\delta}$ and the exploitation regions $R_{\hat{\zeta}\hat{\delta}}$, per raw material; in the solution process, all elements of the matrix that do not correspond with the relevant values of ζ, δ, $\hat{\zeta}$, $\hat{\delta}$ and s are zero; the remaining element $>$ zero

4. THE DYNAMICS OF THE SYSTEM

The economic structure, as reflected in the previous chapters, changes in the course of time. In this analysis, the altering economic structure is reflected continuously. Let the quantities of the static model be indicated by χ and the time by τ. In the specific case that the value of τ is the same as the value of suffix t to χ , it holds that:

$$\chi \equiv f(\tau)$$

Alterations to the quantities in the course of time are presented as:

$$\dot{\chi} \equiv f'(\tau)$$

The point of time t is indicated as period t.

Factor-sparing versus factor-using developments

In present-day economics, technological development is considered to be endogenous. The 'innovation possibility frontier' of C. Kennedy functions as a starting point for theorizing in this field. See, for instance, H.P. Binswanger (1974b) and R.A. McCain (1974). In the analysis presented here, however, technological development is treated as exogenous, yet technology is considered to be subject to control.

In the preceding section it was pointed out that equation (B.5) can be written as:

(B.5b) $$E^{y}_{ki} \frac{y_k}{v_i} = e^{-\varepsilon_{ki}} x_{ki}$$

In accordance with Hick's definition, when ε_{ki} increases we can speak of technological development that saves factor i. For, this alteration in the technological sphere has the same effect as an augmentation of the available quantity of the production factor in question ($\hat{x}_i$). Note that the indication 'factor-saving' does not say anything about the way this saving is realized. If there are no implications for the value of the parameter $\hat{x}_i$, the factor-saving in the model discussed is entirely used in the actual production.

However, if the production factor is a raw material and the exploitation policy is such that the value of the parameter $\hat{x}_i$ diminishes under these circumstances, the saving will benefit the natural stocks. In that case the saving can benefit the economic process in a later period.

Factor-saving tendencies find their expression in positive values of the parameters $\dot{\varepsilon}_t$. The total saving of factor i in k production processes is expressed by:

$$\sum_k e^{-\dot{\varepsilon}_{kit}} x_{kit}$$

The factor-saving refers to a certain period t. Negative values of the parameter $\dot{\varepsilon}_t$. express factor-affecting tendencies. These occur especially with the factors land and labour, as a result of the influence of pollution.

These definitions, however, are not the last word on the sparing of production factors. Factor shares, determined by factor substitutability, also play a part. The alteration of the factor shares E, that result from substitution elasticities changing, also influence the use of production factors. Alterations of the 'effectivities' E_{kit} of raw material i in k production processes, has the following effect:

$$\frac{1}{v_{it}} \sum_k \dot{E}_{kit}\, y_{kt}$$

The effect can be positive as well as negative.

The total effect (F_{it}) on the use of raw material i at period t is given by:

$$F_{it} = \underbrace{\sum_k e^{-\dot{\varepsilon}_{kit}} x_{kit}}_{\text{factor-saving/ factor-affecting effect}} + \underbrace{\frac{\sum_k \dot{E}_{kit}\, y_{kt}}{v_{it}}}_{\text{effect of changing effectivity}}$$

Thus, the total effect consists of two components: a factor-saving or factor-affecting effect, and the effect of a changing factor share. If F_{it} is positive, a factor-sparing effect is manifest; if F_{it} is negative, a factor-using effect occurs.

Intertemporal causality

In the analysis, intertemporal causality is such that certain variables in the static model at a certain period are related to parameters in the static model as extrapolated to a later period. The variables and the parameters mentioned are both variables in the 'dynamicized' model.

The pressure of production on the capacity of land is demonstrated, and it is shown that through the accumulation of effective waste in the environment, the regenerative faculties of land are impeded, especially in the bringing forth of 'products of nature'. This is reflected by a diminishing in the capacity ratios of land ε_X, and thus by negative values of $\dot{\varepsilon}_X$. If the quantity of effective waste is large and constant, ε_X are relatively low and $\dot{\varepsilon}_X = 0$; if the quantity is small and constant, ε_X are relatively high and $\dot{\varepsilon}_X = 0$.

To be able to formulate the impact of the use of raw materials (Q) on the degrees of capacity of land (ε_X), the following concepts must be defined:

- The emission coefficient γ indicates the part of the quantity of a certain raw material, used in a particular production process, that is emitted into the environment.
- The degree of persistency ψ indicates the part of the emitted waste, of a certain origin, that is not absorbed and neutralized by nature in the current period, and therefore can merely disappear in the course of time. See Krabbe and Heijman (1986,p.83).
- The environmental effect coefficient θ indicates the effect of a certain quantity of biological active waste in nature, on the degree of capacity ε_X of land of a certain quality. In this analysis it is assumed that ε_X varies proportionally to the quantity of effective waste.

For a certain polluting raw material (Q) and the capacity of land (ε_X) in a certain application, the following relation can be formulated.

$$\varepsilon_{Xt} = \theta \gamma \int_{t}^{-\infty} \psi^{\tau} Q(\tau)\, d\tau$$

If more waste is emitted than nature can absorb, $\dot{\varepsilon}_{Xt}$ is negative; otherwise $\dot{\varepsilon}_{Xt}$ is zero or positive. The formula must be adapted if the three parameters defined above are altered.

Exploitation of resources

Technological development must be seen in the light of the practice regarding the exploitation of finite natural resources. It can be posited that, given a certain population and a certain area of land, the social welfare U is determined by the volume of the supply of raw materials and by the structure of technology. In the model, the abstraction is from the impact of the market mechanism on the volume of raw materials exploited. Frank and Babunovic (1984,p.90), elaborating this aspect, conclude "that both slow supply adjustment and depletability are important factors in resource markets".

In a certain period t, the amount used from the natural stock $\bar{\bar{Q}}_s$, of material s, is:

$$\hat{Q}_{st} = \xi_s \bar{\bar{Q}}_{st} \quad (s=1,2,\ldots h)$$

The part of the natural stocks that is used per unit of time can be called the exploitation rate. The h exploitation rates are indicated as ξ_s. It can thus be said that, under certain circumstances in the relevant period, the social welfare U_t is given by:

$$U_t = F_t (\hat{Q}_{1t}, \hat{Q}_{2t}, \ldots \hat{Q}_{ht})$$

Yet, the evolution of welfare is also determined by the exploitation rates of natural stocks. This is expressed in Figure 3. In this figure, two development paths are outlined: a path for a comparatively high exploitation rate (a), and a path for a lower rate (b). The idea of 'intersecting extraction paths' is also found in Lewis *et al.* (1979,p.229). The point of time $\tau = \zeta$ is a turning point, in the sense that economizing on raw materials begins to be fruitful.

The impact on welfare is illustrated in the lower part of Figure 3. In this presentation, the super-temporal welfare (W) is:

$$W = \int_0^{\omega} U(\tau)\, d\tau$$

Substituting the two previous functions in the last equation yields:

$$W = W(\xi_1, \xi_2, \ldots \xi_h)$$

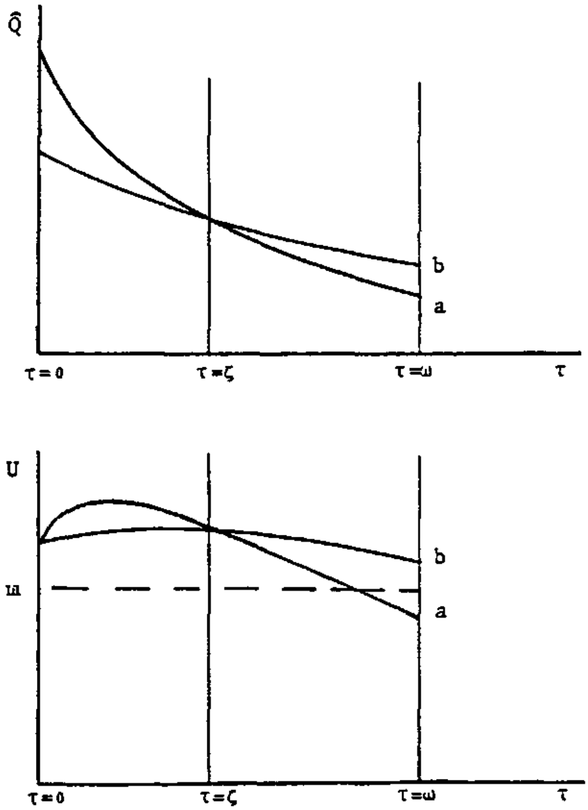

Figure 3. Development of welfare with different exploitation rates of natural stocks

In every period, the price of a unit of labour expresses the earning power of that unit, given the social welfare function as described by the model and given the paths of changing substitution elasticities that correspond to the two development paths of the pattern of scarcity. In the above approach, the abstraction is from the influence of the exploitation rates on the structure of technology.

Suppose the point of time $\tau = \omega$ is the horizon of the exploitation policy. The choice between the two policies outlined is the result of a comparison of the areas below the welfare curves. Time preference, introduced in economic theory by Böhm-Bawerk, might also play a part in the decision in question. In this case, the welfare function must be adapted. In a study done by Withagen (1981,p.506) the rate of time preference (ρ) is included in the welfare function as: $e^{-\rho\tau}$ Time preference strengthens the arguments for opting for policy a. In a political climate in which future welfare is not allowed to fall below a certain minimum, as indicated by m, this consideration leads to policy b being chosen.

Factor substitution appears to be an essential element in western economic growth. The proportion of raw materials used, compared with the quantities of labour and land, is rising steadily. To date, the coherent problems of depletion of natural stocks and pollution of the environment are a direct consequence.

5. DECLINING FUNCTIONALITY OF LAND

In nearly all sectors of agrarian production, the process of industrialization - outside as well as within agriculture - affects the functionality of land. The function of land in the preservation of nature is also affected by this, and by other economic trends as well. In this section these two facets are elucidated.

The pressure of industrialization

In the preceding sections, the impact of the use of raw materials - including energy-bearers - on the capacity of land was indicated by a general formula. Below, this idea is developed further, on the basis of the structured model. The general formula is applied to the most important sources of pollution: industrial mass production (M3), engineering (M2), and industrialized agriculture (A3).

Further, by way of example, the formula mentioned is applied to the effect of these sources of pollution on the capacity of 'barren' land, insofar as this land is designated for the preservation of nature. In this form the function reads:

$$\varepsilon^{A1}_{X1r} = \sum_{s=1}^{n} \theta^{A1X1r}_{Qs} \; \gamma_s \int_{t}^{-\infty} \frac{Q_{M3s}(\tau) + Q_{M2s}(\tau) + Q_{A3s}(\tau)}{\psi^{\tau}} \, d\tau$$

The formula is applicable to various raw materials (s).

In principle, the function can be written in the same way, if the pollution affects land of whatever quality designated for the preservation of nature, as well as for traditional agriculture. This is illustrated in Figure 4. The degrees of capacity ε^{A1}_{X1r} and ε^{A2}_{X2r} can also be interpreted on the basis of the multi-functional variant of the model. In fact, the capacity of land is influenced in a multi-faceted way, according to the number of pollution types concerned. Partial degrees of capacity are ε^{A1}_{X1rs} and ε^{A2}_{X2rs}, respectively. The symbol s in these forms stands for a certain polluting raw material, and the forms themselves represent specific elements of the degrees of capacity concerned. The entire degrees of capacity are defined as follows:

$$\varepsilon^{A1}_{X1r} = \sum_{s} \varepsilon^{A1}_{X1rs} \quad \text{and} \quad \varepsilon^{A2}_{X2r} = \sum_{s} \varepsilon^{A2}_{X2rs}$$

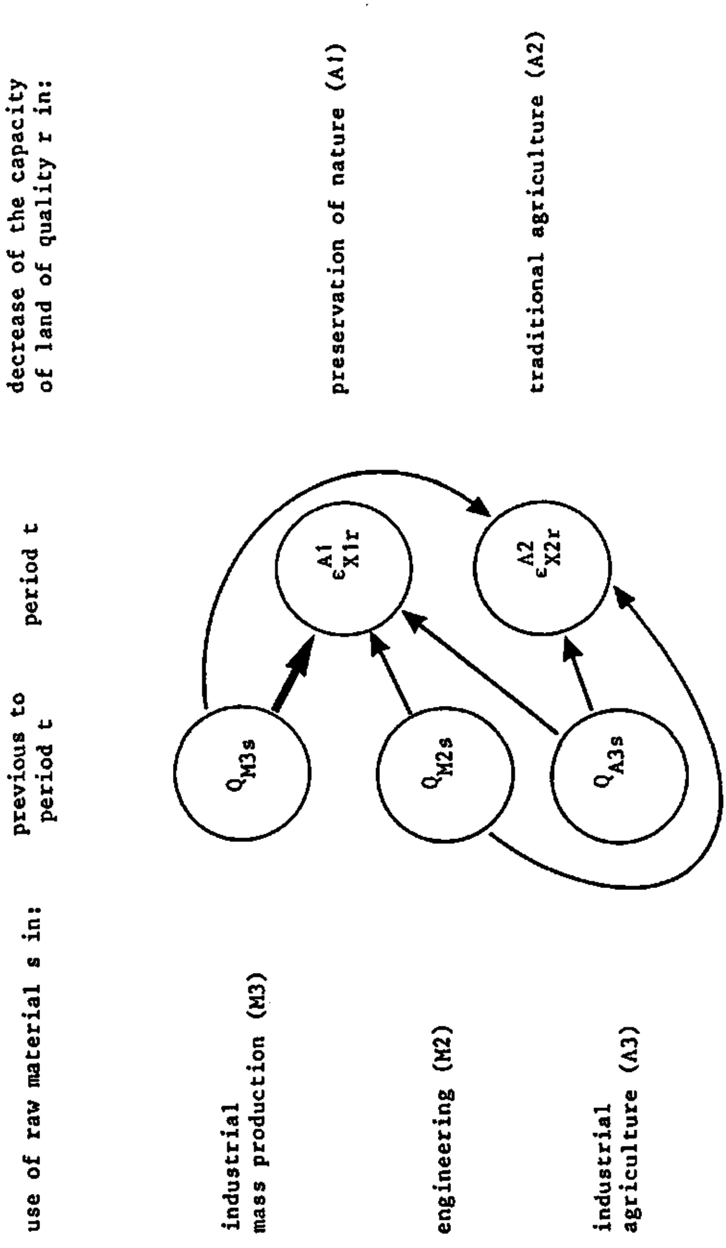

Figure 4. Pressure of the use of raw materials on the capacity of land
The significance of the symbols is in accordance with the structured model.

Thus, the picture of environmental effects is fragmented. Each fragment is typified by the following data: the kind of residue (s), the type of land affected (r), and the process for which the land is designated. A fourth characteristic of each fragment is the spatial aspect of the environmental effect, which is reflected by the location variant of the model. In this context, the last main characteristic is the time aspect of each environmental effect.

The elimination of the unpaid function

Within the agrian sector, systematic alterations in the process of economic development can be noticed. For example: the area of cultivated land is extended at the expense of the uncultivated area. Further, the area designated for industrial agriculture on a large scale is extended at the cost of the area under traditional agrarian use. In this subsection these two phenomena will be incorporated into the analytical scheme.

Western history is characterized by a continuing opening up of new lands. Yet, the picture is rather complicated. Waste areas were sometimes converted into forests, which were to be utilized in one way or other. Later, many of these forests were converted into arable land. In the present century the conversion of waste land into forests and fields, and the large-scale conversion of forests into arable land has come to an end, for a number of reasons. For example, the possibilities for utilizing the land for agriculture are almost exhausted. Further, social appreciation of waste lands and forests has dramatically increased. Finally, it must be mentioned that at present it is generally realized that a continuing conversion into fields disturbs the functioning of natural ecosystems.

Since valuation on the basis of the interests of the owners and users of the land is not always in accordance with the social valuation mentioned, in most western countries further reclamation of land is now restricted by government prescriptions indicating for what purpose the land should be used. This implies that there is no market mechanism that balances the income of the private person or public authority that owns the natural areas against the full social appreciation of these items of nature. The proceeds from forests are, in many cases, not even sufficient to cover the expenses of forest maintenance. Thus, the choice facing the public is paying out government subsidies or accepting neglect.

In developing countries the situation is often different. The need for food is increasing, and in many cases the easiest way to raise additional crops is to occupy natural areas, legally or illegally.

Generally, an increase in agrarian production can also be achieved in other ways, which, however, would require specific skills and institutional adjustments. In this situation too, the social valuation of nature plays too small a role in the pattern of decisions about the designation of land.

When discussing changes within the cultivated area, three main types of 'industrialized' agriculture can be distinguished:

- Monoculture on large parcels of land. This type of agriculture is characterized by a rather high consumption of raw materials and, further, by the characteristic impact of monoculture on natural ecosystems.
- Factory farming. This type is characterized by a high consumption of raw materials and, further, by the unfavourable effect on the environment of the manure produced.
- Horticulture in heated greenhouses. This type is also characterized by a high consumption of raw materials, unless residual heat from other installations can be exploited.

At present, western agriculture cannot be imagined without these typical forms of production. The challenge is not to eliminate them radically, but to reduce their negative effects on the environment considerably. The question is also, how much more cultivated land will be turned over to industrial agriculture, and what is the impact on social welfare of this trend, taking environmental externalities into account?

'Traditional' agriculture has a specific function in maintaining natural ecosystems, and this function is impeded if the areas concerned are involved in industrial agriculture. Just as in the situations described above, from an economic point of view the function is hidden. The general problem is that in the private sphere, these functions are insufficiently represented in the considerations that result in decisions about the way the land is used.

In some areas, government uses the instrument of planological prescriptions to cope with the social requirements. In many cases, however, this does not solve the problem, because there is no certainty that the income of the holders of the land concerned is sufficient to enable them to keep the land in the condition stipulated.

Of course, industrial agriculture is also affected by the effects of pollution. In this sector of agrarian production, however, the possibilities for adapting the production process to altering environmental circumstances are greater than in traditional agriculture and in the preservation of nature. It may even be that in industrialized agriculture, the measures to adapt the process bring production into more conflict with ecological standards.

6. THE PICTURE OF DEVELOPMENT

The degeneration of nature, being the deterioration of the environment for life as well as the depletion of natural stocks, must be seen in the broad context of economic development. In this section this broad vision is discussed. Two contrasting visions on economic development are presented and, after that, both ideas are incorporated into a compound analysis.

Two visions on the process of industrialization

Economic development can be outlined in various ways, according to which causal factors are highlighted. This also applies to the process of industrialization of the western world. In this subsection, two contrasting causal ideas in social development are stated.

Economic science arose from the philosophy of the Enlightenment, a way of thinking that has left a lasting stamp on economic thought. For environmental economics, this has the advantage that explanations of the functioning of nature put forward by natural scientists can easily be assimilated into the pattern of economic thinking. A disadvantage is that economic thought can easily function as a sounding board for aprioristic optimism about economic development in the future. For, welfare optimism, being a long-standing characteristic of economics, is based on enlightened thought. In this philosophy, a continuing interweaving of 'reason' in the thinking about the organization of society, is the propelling force in social development. Thus, a *certain* causality is assigned to the development of reason.

This train of thought contains the idea that the spectacular economic development of the past centuries is merely the result of activities of the human spirit, which, building on the inventions of previous generations, is capable of ever greater achievements. In this vision the use of raw materials is a facet of the relation between man and nature, enabling man to utilize nature ever more intensively. Once a natural resource is exhausted, attention is directed to other possibilities of nature, which always comes up with new solutions in the light of increasing knowledge. Why should one worry about living conditions in the future, with so many proofs of ever-increasing technical and organizational ingenuity?

Nineteenth-century Romanticism functioned as a matrix to ways of economic thinking in which, following in the footsteps of the Physiocrats and Malthus, not human ability but the performance of nature is primarily considered to be the source of welfare. In the Historical school the utilization of nature in an efficient way is a significant topic. The following vision on the process of industrialization can be placed against this background.

Man forms part of a natural system, which gives him a special ability to provide for himself. He has a propensity to use his abilities in such a way that nature deteriorates under the influence of production (see Georgescu-Roegen,1970). In former times, large parts of the earth became infertile, due to overexploitation (deforestration and salinization). In industrial production a similar process of depletion of nature takes place, although on a much larger scale. To afford a small part of the world population an unprecedentedly high standard of life, natural stocks are consumed. Yet, these sources ought to benefit other people and future generations, who have to bear the burden of the pollution of the environment. Who would not worry about the future with so many proofs of mismanagement?

Two causal elements in welfare

In this analytical study, both of the above visions are represented. In this context, the economic aspect of the capacity of the human spirit is called technology. The decrease of the capacities of nature - by depletion of natural stocks, by diminishing the fertility of the soil and by the degeneration of the environment of life in general - is termed the depletion of nature. In this approach, the question of which tendency will dominate is not answered aprioristically. The contribution to the insight into these matters provided here, is merely a scheme of thought, originating in welfare theory.

The two clusters of causal factors that determine the level of welfare, can be distinguished with the help of the following social welfare function, developed in two steps. In the first resort the function is bound to a model with substitution elasticities that are unity. This reduced form of welfare function holds:

$$U_t = U_t\,(\gamma_t, E_t, \epsilon_t, \hat{Q}_t)$$

The explanatory variables, referring to a certain period, stand for collections of exogenous variables of: the emission coefficients γ_t, the production elasticities E_t, the degrees of capacity ϵ_t and the available quantities of raw materials $\hat{Q}_t$. Technological development is expressed by a change of the elements of the first three groups of variables. The depletion of nature is expressed in the elements of the last two groups. Thus, $\dot{\varepsilon}_t$ reflects both tendencies.

If substitution elasticities deviating from unity are accommodated, the welfare function is:

$$U_t = U_t^S (\gamma_t, \sigma_t, \varepsilon_t, \hat{Q}_t)$$

In this form, the collection of production elasticities E_t is replaced by the collection of substitution elasticities σ_t, on the basis of the 'three-by-three formula'. Both functions are bound to the models constructed before.

It is a challenge to technology policy, to direct the technological renewal in such a way that, given a moderate depletion of nature, welfare is maximized. For this, the optimal set of values for $\dot{\gamma}_t$, $\dot{\sigma}_t$ and $\dot{\varepsilon}_t$ has to be found. It is not assured, *a priori*, that the market mechanism will lead to this situation, but neither can the opposite be stated. The government has to construct an institutional framework for private decisions, in the field of technology too, such that company targets are in the line with social requirements in the long run.

In connection with the latter scheme of thought, the phenomenon of population increase deserves special attention. It would be an over-simplification merely to note that welfare, thus analysed, has to be shared between more or fewer people. The size and the development of the population have an impact on technology.

Know-how about industrial and agricultural production can be divided into personal and general knowledge. The significance of personal knowledge is restricted to the function of the individual who possesses that knowledge. General knowledge can be utilized by a broader group, either free or on receipt of payment.

This analysis requires a further examination of the influence of population growth on the level of general knowledge. A growing population may stimulate technology, in an organizational as well in a typically technical respect. Yet, this is not to say that the increase in technical knowledge concerned equalizes or dominates the decreasing tendency for depletion of nature. For, also the number of mouths to feed is increased and, further, still nothing is said about the strength of the effect on welfare that results from technological improvements.

However, it is easy to imagine a situation in which population growth has no positive effect on the level of technology. This would be the case if no proper education or adequate employment and remuneration were available for the increased population. In such a situation, the increase of population might even threaten social stability and, possibly, destroy technology. For, in that situation, economic organization might be disrupted.

7. INTERNALIZATION OF LAND

This section is devoted to the idea of an internalization of land - from the point of view of welfare economics - in order to preserve nature. In this connection it must first be noticed that preservation policy forms part of environmental policy in general. Environmental standards must be placed in a broad spectrum of social goals, which must all be seen in relation to social welfare. On the other hand, the instruments of preservation policy form part of a large collection of political instruments.

For the sake of efficiency, the various achievements in the economic system have to be paid for according to their contribution to social welfare. If these conditions are not satisfied, the scheme of remuneration in society has to be adjusted, to remain efficient. This may be called the principle of internalization of external effects. This principle will be elaborated for the phenomenon of the hidden function of land, described in Section 5. The examination starts with the planological assigning of specific functions to specific areas, which is customary today in most western countries. Further, the grounds assigning of specific functions to specific areas, which is customary today in most western countries. Further, the grounds assigning of specific functions to specific areas, which is customary today in most western countries. Further, the grounds on which payments are made to holders of land are elucidated. Finally, the system of remuneration is discussed.

Planological allocation of land

Planological decisions concern the purposes of land and, therefore, usually affect the value of the land. This interference in property rights has a juridical facet. In this context, however, attention is directed to the purely economic aspect of this type of government intervention. Below, it will be contended that planological prescriptions partly sustain the mechanism of welfare theory in society, and partly frustrate it.

The function of sustaining the strife for social welfare is paramount. A set of correct planological prescriptions corrects the fact that some important social goals cannot be attained because certain effects of welfare are not included in the economic mechanism. As such, planology is an indispensable instrument in welfare policy. The image of the structured model presented earlier, with its multifunctional and location variants, is altered by planological interference which affects the functions of land in the various areas. By so doing, imponderables - in terms of economics - in the sphere of nature are taken into account. The 'price' of this planological interference is, in the first place, the loss of economic welfare, as indicated by the model previously described.

Seen in terms of welfare economics, planology also has an objectionable side, because the incomes of the holders of land that has been given a new designation as a result of planological prescriptions, are still based on the original scheme of typically economic productivity. So, there is a discrepancy between the broad foundation of the system of planological prescriptions, as described above, and the small, typically economic basis of the system of remuneration for the functions of land.

The latter can also be said in the following way. Government limits the functions that a certain area of land may perform, in accordance with a given set of economic and non-economic social goals. Yet, the payment of the functions is based solely on the typically welfare economy scheme, which is frustrated as described. Of course, a planological system that includes proper allowances for officially assigned functions, is not objectionable in this respect.

Grounds for paying subsidies to holders of land

Efficiency in social relations is benefited by internalizing the hidden function of nature in the economic system of achievements and rewards. Yet, the question arises, what criteria have to operate when deciding whether to pay a subsidy to a holder of land, either an owner or a user? The answer cannot be that the holder of land is subsidized for the full social value of the piece of nature he is administering. There is no justification for this and, moreover, it would be impossible in practice.

The following principle is more in line with the philosophy of welfare economics. A factor of production, whether or not it generates a positive externality, is rewarded in such a way that the supply of this factor endures. This principle, still rather vaguely formulated, is also applicable to remuneration for the functions of nature, insofar as these are to be achieved with human help. In this connection two situations can be distinguished: the situation in which the holder of land is legally obliged to perform certain duties that benefit nature, and the situation in which it is merely appreciated by society that the holder of land administers the property in a certain way.

An example of the first situation is the forester who is under obligation to remove fallen trees and to reforest after cutting. If it is clear that wood prices are too low to cover these expenses, an allowance to the forester would be justified. Alternatively, the law might become flouted on this point. Another alternative in such a situation is to sell the forest to the government, which then has to render these tasks itself.

An example of the second situation is as follows. In a certain area, society, through its representative the government, prefers agriculture to be carried out in a traditional way, for instance to prevent the landscape from running wild or to avoid the disadvantages of industrial agriculture. In this situation, the farmer is still free either to stop his undertaking or to industrialize the production process. In this case too, a subsidy is justifiable according to welfare theory.

The size of the subsidy not only determines the efficacy of this instrument in the short run, but is also of importance to the impact on nature in the long run. A low payment will merely stimulate the agricultural population to continue their activities in the usual way. A payment that is sufficiently high, however, will also stimulate the rejuvenation of the staff in forestry and agriculture, including the adoption of adequately renewed techniques

The system of payments

Finally, let us consider the source of the remuneration to reward constructive externalities in forestry and agriculture and, further, how this remuneration can be carried out in principle. The costs of the subsidies described above are just a small part of the expenses to spare nature that have to be borne by society. For, these expenses include the enormous costs of environmental technology. By far the largest part of the latter costs are borne by enterprises; the remainder have to be paid for by the government and form part of total government expenditures.

At the end of the last century, Henry George propagated the idea that govenment expenses could easily be covered by the rent paid for land. Scarcity of land, said George, would become increasingly acute and, therefore, rent would rise steadily. Government would merely have to appropriate the rent for land, to tap an abundant source of income.

From the foregoing sections it is evident that, as far as the rent of land used in agriculture is concerned, George's prophecy has not been fulfilled. Concerning raw materials, however, it appears that at present an increasing scarcity is anticipated. Therefore, in accordance with this expectation, higher prices for raw materials will be functional, insofar as these are based on growing exploitation costs and increasing royalties.

A propos the latter: Backhaus and Wagner made clear that covering government expenses out of royalties is an old principle in public finance. Under present circumstances, it would be a rational political idea to use this financial resource to cover government expenses for sparing nature. Payments to holders of land, for rewarding the hidden function of nature, could be executed in two ways. The allowance could be given per person working in a clearly described way to preserve nature. Another possibility is to pay the allowance per specific nature-benefitting achievement.

8. THE POLITICS OF ENVIRONMENTAL TECHNOLOGY

Technology is an important determant of welfare. In this context, welfare is conceived of as the standard of life, including the quality of the environment as well as the level of provision with products. The character of technology depends on certain laws of nature, which are controlled by man. In environmental technology policy, which is the main topic of this section, the forces of nature are taken as given and attention is concentrated on the potential for manipulating these forces.

What aspects of technology are of interest from a political point of view? How is the institutional framework of interest to the development of environmental technology and what policy scenarios would promote this kind of technical progress? These three problems are discussed below. The scope of the analysis is determined by the properties of the model elaborated earlier.

Aspects of technology policy

In the previous model, technological change influences welfare by altering the parameters ε and σ - which express the capacity of factors of production and the inter-factor substitutability, respectively - and, implicitly, by altering the effectivities E. Further, technology has an impact on social welfare via the values of the emission coefficient γ.

However, in general these exogenous variables do not vary independently. An innovation usually influences some of these parameters simultaneously. An improvement in the field of recycling, for instance, has a direct factor-saving effect, reflected by $\dot{\varepsilon}$, expressing the saving of the raw material. Moreover, this innovation has an effect on the level of pollution, reflected by $\dot{\gamma}$. The impact of the decrease of the emission of waste on the fertility of land has already been discussed. Notwithstanding this complexity an attempt will now be made to outline the features of technological change from the standpoint of preservation of nature. First, forms of factor-saving technologies will be discussed; then, factor-sparing technologies will be examined, taking the substitution aspect into account.

The factor-saving tendency is the main feature of any technological development, and thus also of environmental technological development. The latter is expressed by positive values of the parameters $\dot{\varepsilon}$, related to factors from the category 'nature'. After discussing the increase in the capacity of land the saving of raw materials will be elucidated.

Each improvement in the use of the soil, whether in agriculture or in the preservation of nature, means a direct increase in the capacity of land. An indirect increase in the capacity of land can be caused by diminishing the environmental pollution that results from industrial production processes. Therefore, in principle, any change in production techniques - including changes in the organization of production - which diminishes the emission of waste, can be considered to be 'land-saving'.

The saving of raw materials appears in many forms of innovation and includes every economy in the use of materials. In this context, prolonging the life of durable products deserves particular mention. Advanced recycling techniques also increase the values of ε that are related to raw materials. How the saving of raw materials is realized is a pertinent question. Will the saving benefit the current production process, or will it be reserved for production processes in the future? This subject has already been discussed.

Another important feature of technological change is the aspect of factor substitution. The replacement of a certain production factor from the category 'nature' by a less scarce factor from the same category can be seen as technological progress from an environmental point of view, provided that prices properly express scarcity ratios. In the terminology of this analysis, such technological changes are designated as factor-sparing if the income shares of the scarcest factors also decrease.

The latter also holds if the invention implies replacing nature by labour, if this is economically attractive. However, many inventions imply combining labour with more 'nature', e.g. raw materials. Such innovations may indeed temporarily increase welfare but nonetheless this development cannot be considered to be technological 'progress', from an environmental point of view. In this analysis such changes are indicated as factor-using, if the income share of nature increases. Note that on the basis of a substitutability of $\sigma = -1$, labour can also be replaced by nature. This is especially the case if wages are relatively high. From an environmental standpoint it is desirable to keep wages comparatively low and to assign the remainder of available wealth directly to the members of society.

Henry George's contention that the rent of land would increase steadily in the course of time proved to be unfounded. Applied to the royalties obtained by the exploitation of raw materials, however, the idea is more realistic. It has already been noted that, according to Backhaus and Wagner (1986), covering government expenses out of royalties is an old principle in public finance. In the present context the interest of this fiscal construction is that wages can be kept relatively low without welfare being affected.

Institutional incentives

What is the impact of the market mechanism, and the institutional framework in general, on the development of environmental technology? Three factors of this broad problem will be elucidated below: the realism of welfare theory in general, the complications in the allocation of production factors from the category 'nature' in this theory, and the question of the ratio between nature and labour in the economic process.

Welfare theory reflects the economic process in a very simplified way. A number of assumptions represent essential aspects of reality. Alas, in this analysis a great deal of interdependancy in economic life must be neglected. In fact, to a greater or lesser extent reality deviates from the ideal of pure competition, welfare maximization and cost minimization. Insofar as the welfare theory model is realistic, it remains to be ascertained whether the effects that will in principle occur are also significant. Thus, empirical verification must indicate to what extent the theoretical model is realistic.

Welfare theory is a reflection of the market mechanism. Prices express the scarcity of the various production factors. In practice, however, the prices of raw materials do not always reflect the social value of these factors, but are in fact lower. This might be the result of the short-sighted exploitation policies of the firms or government bodies in producing countries.

To approximate the optimal prices in the welfare theory model, specific royalties or turnover taxes could be raised. However, this creates the following problem: the degree of scarcity of a production factor is also determined by the level and the structure of technology. A price of a raw material that is not very low is an incentive for technological development in which the possibilities of using that material increase. The resulting innovations increase the value of the raw material in society's eyes. A levy on the use of this raw material, after the innovation has been adopted, would bring its actual price to the level of the ideal optimal price. On the other hand, this price increase places restrictions on the possibilities for the profitable application of the innovation, thereby discouraging inventors from proceeding further. Thus, the government must in no way affect the reasonable profit expectations of the firms involved in research and development.

There is another problem to do with the approaching of optimal conditions. Many economists have not included taxes in the welfare theory model. But if taxes are to be included, on which factors must they be levied? In most countries the labour factor is taxed the heaviest. This implies that it is to a large extent profitable to substitute raw materials for labour. Such a tax system has a factor-using effect and, moreover, under unfavourable circumstances it creates unemployment too. From an environmental point of view there are no grounds for exempting raw materials and capital - which incorporate a considerable amount of materials and energy - from tax.

The self-regulating forces within an economy that is on the point of developing environmental technology are conditioned by various circumstances: the preservation of nature has to be an objective of the producers. This objective must be given sufficient weight in company decisions. Furthermore, the private activities concerned have to be paid for in accordance with the unavoidable costs attached to this objective. Because these conditions are not fully fulfilled, additional government measures are necessary.

Technology scenarios

The looming environmental crisis makes it desirable to draw up a radical preservation policy. Such a policy - based on how an optimal situation is seen - will have three dimensions, according to the period in which the measures must be effectuated. Thus, there are scenarios for the short, the intermediate and the long term.

The short term is determined by how long it takes for most production plants to depreciate. It must be realized that for the necessary internalizing of environmental effects to take place, production circumstances will alter as follows:

- A number of plants will have to close, because the producers will be confronted with drastic increases of costs.
- A number of plants will be able to continue at current production levels, thanks to radical changes in technology.
- A number of the existing plants, and a number of new plants will be confronted with new possibilities, which can be exploited by new technologies.

This scenario of the restructuring of the production process could be completed - and accelerated - by a system of subsidies and tax reductions.

The intermediate term is determined by the period in which sensible speculations can be made about possible innovations in the sphere of environmental technology. If the market incentives appear to be strong enough to bring forth these innovations automatically, government can remain passive. If, however, these incentives are not sufficiently effective, the government can reinforce them; for instance, by granting fiscal exemptions. Finally, the government could also stimulate the development of environmental technology, by placing research orders with specialized firms and public research institutes.

The long-term scenario concerns the institutional aspect of the economic process. It contains a plan for converting comparatively nature-using economic order into an institutional system with a nature-sparing character. The present institutional framework can be typified as nature-using for three principal reasons: in the market system nature is systematically undervalued; further, the present fiscal system is unfavourable to the preservation of nature, and, finally, social preferences are for the greater part oriented on material goods.

Thus, for the long-term scenario the government has to ensure that prices reflect the scarcity of nature. Here, it must be remembered that nature ought to be at the disposal of all mankind, and not just of a few generations of a part of the world's population. Secondly, the fiscal system has to be changed in such a way that the use of nature is discouraged rather than encouraged.

The third point concerns the structure of preferences in society. In the previous analysis, in order to keep the explanation as clear as possible, preferences were assumed not to alter in the course of time. In that context technological development in the service sector is of the nature-sparing type, if the income share of the labour factor is increased. This tendency is reinforced considerably if the focus of the preferences shifts from material goods to services. This institutional alteration benefitting the preservation of nature implies a change in the substitution elasticities in the sphere of welfare.

9. PUBLIC CHOICE AND THE PRESERVATION OF NATURE

To close this study of the welfare economics of the environmental problem, attention will focus on the question of the division of tasks between the private and the public sector in the social strife for welfare, which includes the quality of the environment of life. First, however, the concepts to be used need to be discussed. Thereafter, attention will be paid to the government as a producer of 'environmental quality', in a direct sense. Further, the government will be presented as an institution that can manipulate the activities in the private sector to fit into the scheme of social purposes. Finally, the relation between welfare theory and systems theory will be discussed in this context.

Two indices of welfare

Two indices of welfare, in the sense of wellbeing, can be conceived: an index of the satisfaction of wants by typically economic goods, and an index of the quality of the environment of life. These indices can be defined as follows:

The social welfare function can be written as

$$U = F(x_1, x_2, \dots x_m, q_1, q_2, \dots q_n)$$

In this function the variables x_r $(r = 1,2,\dots m)$ represent typically economic goods, i.e. goods that are not intended to preserve nature. The variables q_s $(s = 1,2,\dots n)$ are quantities of a physical nature that characterize the n positively valued properties of nature as a matrix of life on earth.

The above function is based on the preferences of individual households, under the condition that certain conditions for aggregation are satisfied. The most important conditions are as follows: In a static analysis, the division of income in society is given. The individual indifference curves all have a normal shape. All individual households prefer to have more of each good and each property of nature, as described above, rather than less. (Krabbe, 1974)

The welfare function stated above can be replaced by the following three equations: an overall welfare function and two partial functions. The overall welfare function is:

$U = U(x, q)$

The first partial function is:

$x = U_x(x_1, x_2, \dots x_m)$

In the context of previous models, the variable x represents the value of the production, excluding the value of the attempts to preserve nature. It is the index of typically economic goods.

The second partial function is:

$q = U_q(q_1, q_2, \dots q_n)$

The properties of nature, represented by the variables q_s, are considered to vary under the influence of the production of goods x_r. The variable q is the index of the quality of nature.

If there is no production directed to the preservation of nature, the production possibility function has the following form:

$\hat{Y} = Y(x_1, x_2, \dots x_m, q_1, q_2, \dots q_m)$

In this function the parameter $\hat{Y}$ indicates the level of the production possibilities, and Y expresses the implicit function concerned. The function describes all possible values of x_r and, further, the corresponding values of the variables q_s, that in this presentation of the function cannot vary independently. Of course, the function holds under the condition that certain quantities of production factors are available and of a certain technology.

In Figure 5 three stages of economic development are outlined with respect to the values of the indices x and q. Figure 5.I is an idealized representation of an agrarian economy. The production of goods is on a rather low level, but the impact of the production on the environment of life is experienced as very positive. Yet, welfare is just at level U_1, indicated by vector h_1. In Figure 5.II a situation is outlined in which the process of industrialization has been started. Production has risen, but negative effects on the environment are also noticeable. In this situation welfare has risen to U_2, indicated by vector h_2. In Figure 5.III the situation of further economic growth is reflected. Now, welfare has risen to U_3, shown by vector h_3. Yet, taking all properties of the environment into consideration, the quality of the environment is experienced as negative. This scenario ignores specific problems arising from the intertemporal comparison of the quantities x and q.

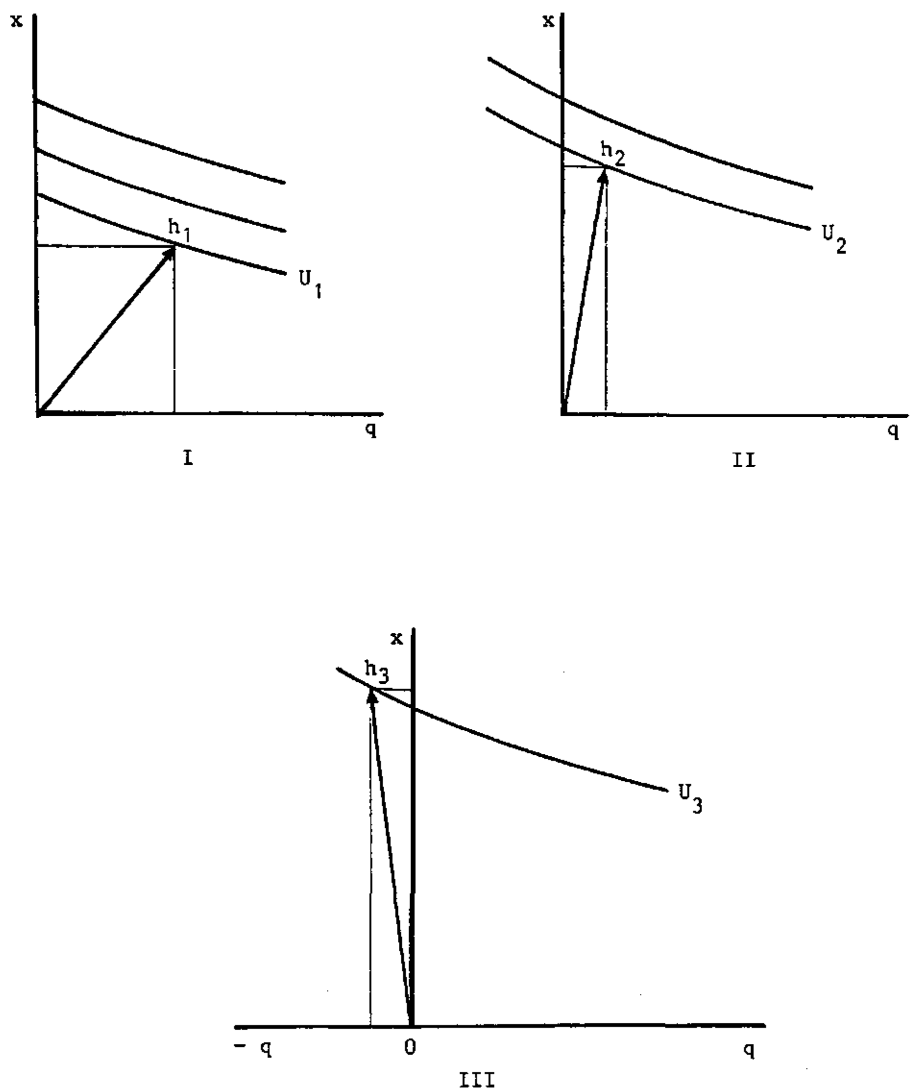

Figure 5. Values of the production index (x) and the quantity index of nature (q) in three stages of development

Complementary environmental policy

The type of environmental policy to be discussed first is formed by government initiatives to improve the environment of life, without interfering in the production circumstances in the private sector. This type of government activity, to maximize social welfare, is complementary to private production. Examples are: the construction and maintenance of sewerage and other systems to remove waste, and projects to preserve the landscape, flora and fauna.

To include this aspect of environmental policy in the welfare theory analysis, the number of m economic goods is divided into: a number of k privately produced goods and a number of m-k social goods, produced by the government. Thus, the social welfare function can be written as:

$$U = F\,(x_1, \dots x_k, x_{k+1}, \dots x_m, q_1, \dots q_n)$$

This function can be split up into a number of equations: an overall welfare function, some equations of definition and four partial welfare functions.

The overall welfare function is:

$$U = U\,(x, q)$$

The first equation of definition is:

$$x = x_f + x_g$$

In the last equation, x_f is a production index of private goods; x_g is a production index of social goods. 'Environmental goods' are excluded from both quantities.
The second equation of definition is:

$$q = q_f + q_g$$

In this form q_f is an index of environmental quality, insofar as the properties of the environment are affected by private production; q_g is an index of environmental quality, insofar as the properties concerned are determined by production of the government.

The partial welfare functions are:

$$x_f = U_{xf} (x_1, x_2, \dots x_k)$$

$$x_g = U_{xg} (x_{k+1}, x_{k+2}, \dots x_m)$$

$$q_f = U_{qf} (q_{f1}, q_{f2}, \dots q_{fn})$$

$$q_g = U_{qg} (q_{g1}, q_{g2}, \dots q_{gn})$$

In these equations, q_{fs} stands for the value of the property s of the environment of life, insofar as this property is determined by private production; q_{gs} stands for the value of property s, insofar as determined by government production. The last equation of definition is:

$$q_{fs} + q_{gs} = q_s \ (s=1,2,\dots n)$$

In fact, the second equation of definition depends on the last one, and is inserted solely for the sake of clarity.

In this analysis, the production possibility function is also separated and is represented by two mutually interdependent functions. The first partial possibility function is:

$$\hat{X} = X (x_1, x_2, \dots x_k, q_{f1}, q_{f2}, \dots q_{fn})$$

In this function $\hat{X}$ is a parameter determining the production possibilities in the private sector, and X describes the implicit function. The values of q_{fs} are determined by the values of x_r ($r=1,2,\dots k$). The function is only determined if the production in the public sector is given. The other partial production possibility function is:

$$\hat{G} = G (x_k, x_{k+1}, \dots x_m, q_{g1}, q_{g2}, \dots q_{gn})$$

In this function $\hat{G}$ expresses the level of the production possibilities in the public sector, and G describes the implicit function. Also, the variables q_{gs} vary independently from the variables x_r, because government policy is partly directed to the various properties of the environment. The function is only determined if the production in the private sector is given. The overall production possibility function is given by the following implicit function.

$$\hat{Y} = \Gamma (X, G)$$

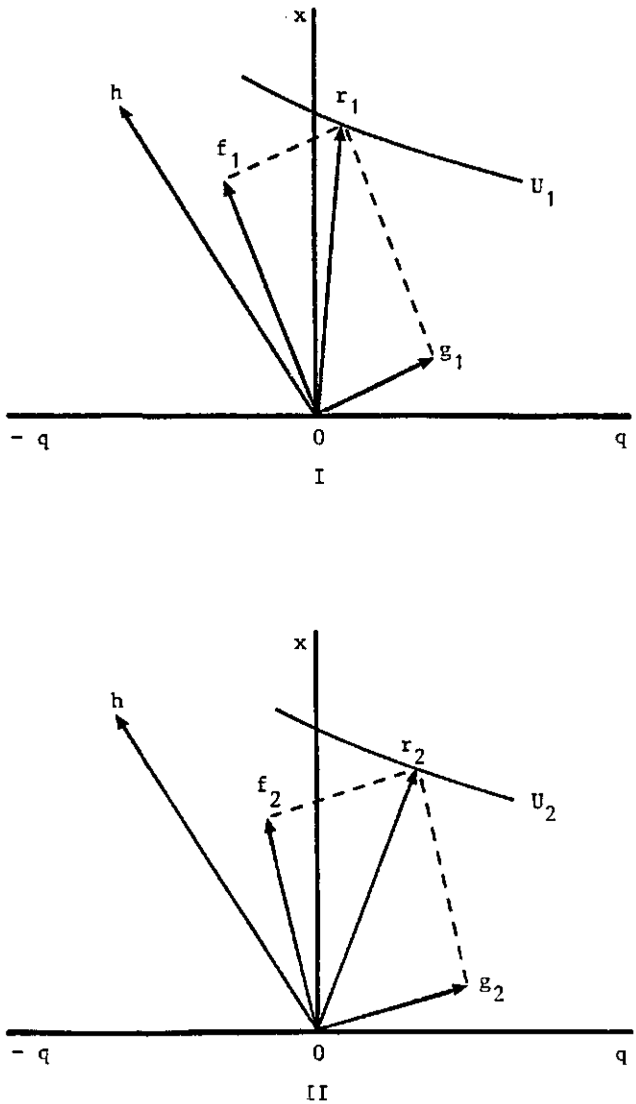

Figure 6. The result of complementary environmental policy: two situations

The above hypothesis of complementary environmental policy is illustrated by the two images of Figure 6. The vector h is based on the ideas of the previous figure: no distinction has been made between private and social goods; there is no question of environmental policy. Figure 6 shows that a 'complementary' environmental policy leads to a higher level of welfare. Further, in the figure two components determine the level of welfare: private production, reflected by vectors f_1 and f_2, and production by the government (including the achievement of complementary environmental policy), reflected by the vectors g_1 and g_2. The resultants are represented by the vectors r_1 and r_2, respectively.

Situations I and II concern the same possibility function Y referred to earlier. Yet, $f_1 > f_2$ and $g_1 < g_2$. Whether the level of welfare U_1 is higher or lower than U_2 cannot be inferred from the foregoing descriptions. Suffice it to state that in the welfare optimum the positive effect on welfare caused by an increase of government expenditure at the expense of private production is equivalent to the negative effect of the corresponding decrease of private production.

The analysis can be extended by including the consideration that production of 'environmental goods' can also be realized in the private sector. In the context of this analysis the choice between private production and production by the government is not ideologically determined. The question is merely in what way a certain social goal can be realized the most effectively. Therefore, in the context of this study the problem of privatization versus socialization is a question of efficiency and environmental technology.

Interventionist environmental policy

Obviously, an industrial society cannot be sustained by a 'complementary' environmental policy. A policy of creating conditions for private decision-making will also be necessary. With this type of policy the government adapts the framework to the decisions of individual households - consumers as well as producers - in such a way that individual decision-making is attuned to social goals.

The question here is what is the legitimacy of the corrective intervention of the government? For, in an individualistic vision of society, such as in welfare theory, the preferences of the various members of society form the basis of social order. These preferences are expressed in the market mechanism. Yet, on what grounds must the government stipulate that this behaviour be modified?

The metaphor of the 'prisoner's dilemma' serves as an answer to this question. In this metaphor consumers - and also producers - are looked upon as prisoners in a system in which no communication is possible. An example is the purchase of an automobile. The buyer would be willing to buy a car with a 'clean' motor, taking the quality of the environment into consideration too, because this is also in his interest. However, he fears that he will be one of the few who make this decision. In that case the effect on the environment would be negligible, while the personal wants of the buyer of the car would not be optimally satisfied. This shows the lack of a communication system between buyers.

In this line of reasoning the justification for the correcting intervention of the government is to provide a communication system with the help of the political system. The solution might be found in subsidizing 'clean' motoring.

The value of the metaphor of the prisoner's dilemma is that the idea of autonomy of individual preferences is reconciled with the idea of government intervention in market conditions. Another keystone in government policy is in the philosophy of an organistic society. (Krabbe,1987)

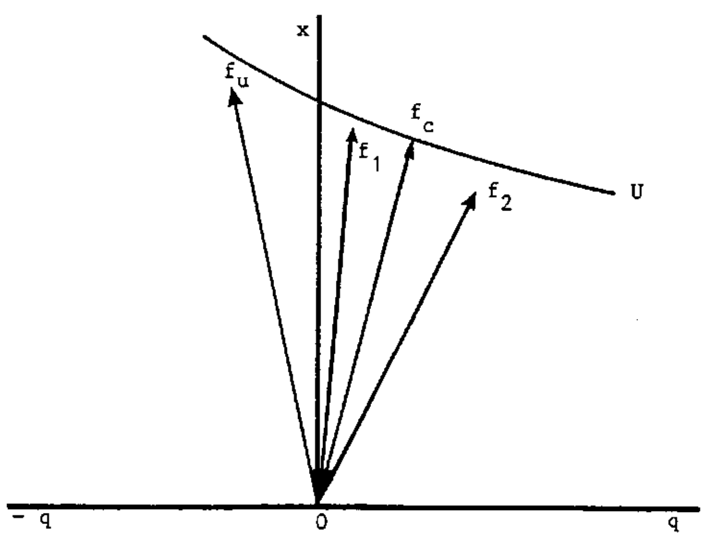

Figure 7. The result of interventionist environmental policy.

The government controls the decision framework of households by means of prescriptions, specific levies and subsidies. These measures are, to a greater or lesser degree, at the expense of the production of 'material' goods. The result of the interventionist policy is outlined in Figure 7, in which it is assumed that there is no government production and thus no complementary environmental policy either. Without any environmental policy, the welfare is indicated by the 'uncorrected' vector f_u. Optimally corrected, the private production is reflected by vector f_c. Another interventionist policy may result in a production as characterized by vector f_1. In this case, however, the effect on the environment is considered to be too small. A production as typified by vector f_2 can also be imagined. Yet, in that case the sacrifice of economic goods is considered to be too great.

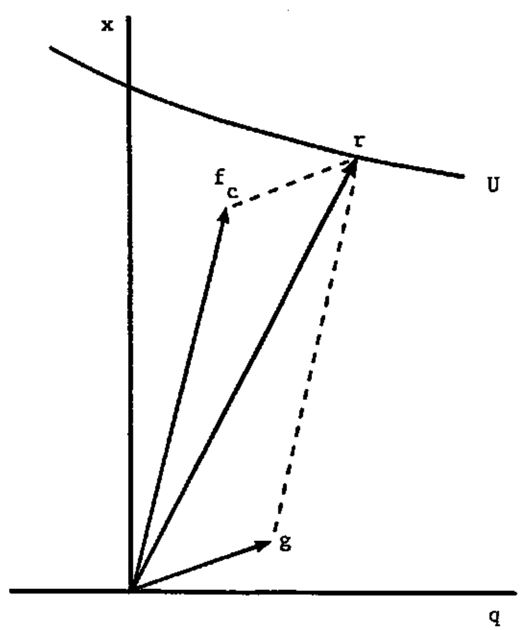

Figure 8. The result of a compound environmental policy

Environmental policy can be conceived of as a compound of complementary and interventionist policies. In Figure 8 component f_c represents private production, as corrected by interventionist policy; component g represents government production, with the environmental element that is described. The resultant r indicates the highest level of welfare that can be attained.

Welfare theory and systems theory

The system of welfare theory can be inserted into a broader framework of systems theory. From the point of view of public choice in environmental economics, the scheme of Figure 9 may be clarifying. The variables of environmental welfare economics refer to the supply circuit of production factors, products and waste. Information needed to make appropriate economic decisions is borrowed from the information circuit. The transfer of purchasing power, to let the system function, is effectuated through the income transfer circuit.

The dynamic aspect of welfare theory, amply elaborated above, can also be expressed in this scheme. In this way, it is stressed that the environmental problem is not a question of another yearly mutation in economic circumstances, but is a question of flows. The flows in question are the exhaustive flows of raw materials and, causally connected with these, the growing flows of waste, including hazardous radio-active residues.

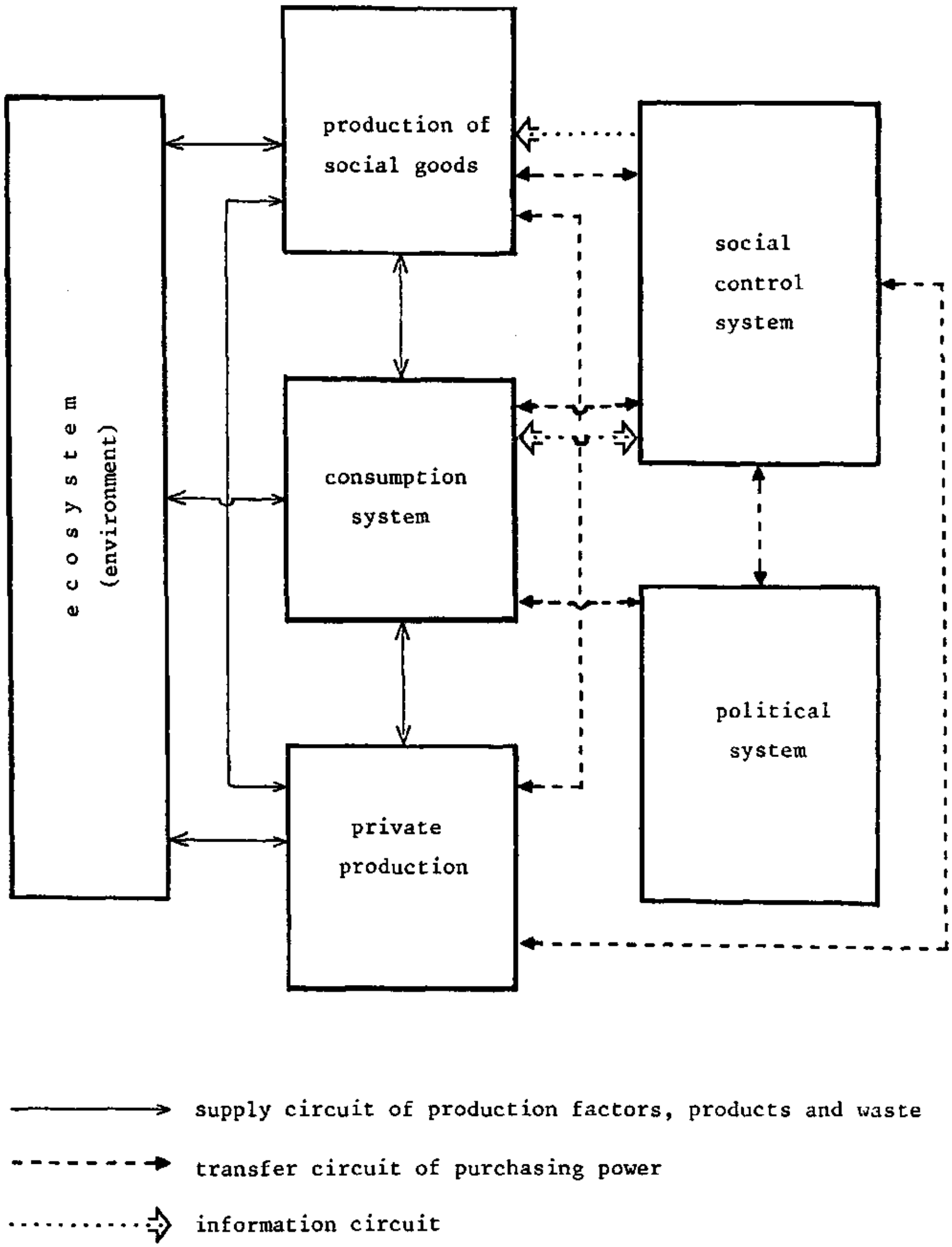

Figure 9. The social economy as a system

10. CONCLUSIONS

The phenomena exposed in this study, being in the field of the economy as well as of nature, are already known. Yet, some of the ideas concerned are only partially integrated in welfare economics. The aim of this study is to incorporate such ideas into a coherent scheme of thought, in accordance with the principles of welfare theory. The points that are worth noting in this connection are reviewed below.

Characteristics of the model

The static basic model is such that, in principle, the whole gamut of substitution elasticities between products and production factors can be expressed. A condition is that the substitution elasticities fit in a scheme in accordance with the 'three-by-three formula'. This condition restricts the possibilities of reflecting empiricism. Nevertheless it does not affect the heuristic value of the model.

It appears to be possible to extend the model so that multifunctional use of land is reflected. It also appears to be possible to formulate the basic model as a location model, in accordance with the Thünen tradition.

The model is 'dynamicized' with three coherent causal factors: the depleting exploitation of natural stocks, the emission of waste, and technological development.

Factor substitution

Progress in environmental technology is considered to be factor-sparing. In this concept two components are distinguished. The first is the factor-saving element, in the Hicksian sense. The second component is connected with the change of the factor share in the income, and is determined by substitution elasticities in the sphere of production.

As regards the mutual substitution of raw materials and labour, the following is concluded. If wages are comparatively low, a high substitutability is favourable. If wages are high, a low degree of substitution is desirable. In this connection it can also be posited that, under certain circumstances, asymmetry in substitutability is favourable and qualifies for inclusion as an objective, when designing the structure of technology. The realization of optimal degrees of substitution, in connection with an optimal exploitation policy of natural resources, appears to be an important target in environmental technology policy.

Functions of land

For the study of the degeneration and the regeneration of nature, it also appears to be useful to design a dynamic welfare theory model on the basis of a static basic model. The latter is suitable to reflect the substitution process between land, raw materials and labour. This substitution process forms an essential element in the explanation of the present environmental situation from the point of view of environmental economics, as well as in the philosophy of environmental politics.

An important aspect is the phenomenon of eliminating the unpaid function of the factor nature. The function concerned is the contribution of 'traditional' agriculture and of forestry to the preservation of nature. It is apparent that an internalizing of this function is socially constructive.

Environmental technology policy

Factor substitution appears to be an essential element in western economic-growth. The proportion of raw materials used, compared with the quantities of labour and land, is rising steadily. To date, the coherent problems of depletion of natural stocks and pollution of the environment are a direct consequence. Cutting this fatal tie is perhaps the most ambitious as well as the most urgent objective of present-day technology policy.

From an environmental point of view, three policy scenarios must be designed, directed to the restructuring of industry, the stimulation of environmental technology, and the adaption of the institutional framework of production and consumption. The institutional alterations must be such that labour is comparatively cheap, in order to minimize the substitution of raw materials for labour.

Preservation of nature in public choice

Two types of preservation policy can be distinguished: a complementary policy and an interventionist policy. The first is included in the rational considerations about the size of government production. The latter is necessary to bring goals in private production into line with social goals. To reflect all facets of welfare theory, in this context the scheme of thought can be broadened to a systems theory.

This essay is an attempt to extend welfare theory in a realistic way. Not all aspects have been dealt with fully and therefore further studies will be necessary.

'MILIEU-ECONOMISCHE WELVAARTSTHEORIE'
A Reproduction in Dutch

De idee van de milieu-economische welvaartstheorie heeft verschillende facetten, waarvan de belangrijkste worden belicht. Er wordt een model gehanteerd dat drie categorieën produktiefactoren bevat: land, grondstoffen en arbeid. De afgeleide factor kapitaal wordt niet expliciet verantwoord. Het statische basismodel kan worden gekarakteriseerd als 'dualistisch', in de zin dat zowel prijzen als hoeveelheden endogeen zijn. Parameters van het statische model zijn: de totale hoeveelheden aangewende produktiefactoren, de grootheden die de mogelijkheden van de produktiefactoren weergeven, en de grootheden die de welvaartsfunctie bepalen. Sommige van deze parameters zijn variabelen in het 'gedynamiseerde' model. De dynamiek van het model is zodanig, dat zowel de degeneratie van de natuur onder invloed van de produktie wordt weergegeven, als de regeneratie ervan door de ontwikkeling van de milieu-technologie.

Het statische basismodel
De studie is gericht op systematische veranderingen van de produktiefactor natuur, in de loop van de tijd. Daarbij gaat het om de gevolgen van het verbruik van onvervangbare natuurlijke voorraden en die van de emissie van afvalstoffen enerzijds, en de implicaties van verschillende vormen van technologische ontwikkeling anderzijds. Dit beeld wordt geanalyseerd in termen van een welvaartstheorie van de signatuur van Pigou. Het denken is in eerste instantie georiënteerd op een statisch model van algemeen evenwicht. Vervolgens wordt het model in kwestie 'gedynamiseerd'. Deze dynamisering is zodanig dat sommige parameters van het statische model fungeren als variabelen van het dynamische model.

Met betrekking tot het basismodel valt het volgende op te merken. Het principe van dualiteit van lineaire modellen wordt in de economie vooral toegepast op systemen waarin prijzen van goederen als variabelen fungeren en de betreffende hoeveelheden als parameters, dan wel omgekeerd: de hoeveelheden als variabelen en de prijzen als parameters. Ook het in dit verband gepresenteerde model bevat de additieve functies uit de genoemde modellen. Het gaat hier echter niet om een stelsel van lineaire vergelijkingen. Bij de oplossing van het stelsel van vergelijkingen dienen prijzen en hoeveelheden in één procedure te worden bepaald. Met het oog hierop wordt gesproken van een 'dualistisch' model.

Het 'elementaire model' is zo geformuleerd dat het kenmerken heeft van de Cobb-Douglas produktiefunctie en die van een sociale welvaartsfunctie welke ook in de 'Cobb-Douglas vorm' is geschreven. De substitutieëlasticiteiten, in zowel de produktie- als de behoeftensfeer, hebben in dit model dus alle de waarde één. Parameters zijn de produktie- en welvaartselasticiteiten, alsmede de totale hoeveelheden van de diverse beschikbare produktiefactoren.

Het elementaire model wordt zodanig aangepast dat, althans in principe, ook substitutieëlasticiteiten met waarden die afwijken van één kunnen worden weergegeven. De grootheden die in het voorgaande model fungeren als produktie- en welvaartselasticiteiten, en daar het karakter hebben van parameters, zijn variabelen in het uitgebreide model, aangeduid als het 'basis model'. In het laatstgenoemde model worden de betreffende grootheden aangeduid als 'effectiviteiten'. De effectiviteiten geven de delen van het inkomen aan die aan de diverse produktiefactoren toevallen, respectievelijk de delen van het maatschappelijke inkomen die aan de diverse produkten worden besteed.

In het laatstgenoemde model, het statische basismodel, zijn de substitutieëlasticiteiten parameters. Hierbij valt op te merken dat het stelsel van vergelijkingen slechts bepaald is als men te maken heeft met bepaalde aantallen substitutieëlasticiteiten. Dit is bijvoorbeeld het geval als men drie produktiefactoren en drie produkten in het model opneemt. Bij een kleiner aantal is dit model onderbepaald; bij een groter aantal is het overbepaald. Het is mogelijk grotere aantallen produktiefactoren en produkten op te nemen, als men deze grootheden in een bepaalde structuur plaatst. Naar deze typische structuur wordt verwezen als gesproken wordt van de 'drie-bij-drie-formule'.

In het basismodel kan het substitutieaspect op een genuanceerde wijze worden weergegeven, dank zij de invoeging van twee groepen hierop gerichte vergelijkingen. Om de modellen overzichtelijk te houden zijn deze vergelijkingen niet opgenomen in de uitgewerkte modellen. Wel wordt er naar verwezen in de toelichting op deze modellen.

Het basismodel wordt gestructureerd overeenkomstig de drie-bij-drie-formule. De produkten worden ingedeeld in de categorieën: agrarische produkten, industrieprodukten en diensten. De produktiefactoren worden ingedeeld in de categorieën: land, grondstoffen en arbeid. De categorie agrarische produkten bestaat uit de subcategorieën: natuurbehoud, traditionele landbouw en geïndustrialiseerde landbouw. De categorie industrieprodukten bestaat uit de subcategorieën: handwerk, 'engineering' en massaproduktie. Voorts bestaat de categorie land uit: woeste grond, land van geringe produktiviteit en zeer nuttig land. De categorie grondstoffen bestaat uit: grondstoffen die latent schaars zijn, enigszins schaarse grondstoffen en zeer schaarse grondstoffen.

Uitbreidingen van het statische model

Het statische basismodel wordt in twee richtingen uitgebreid. De eerste uitbreiding is zodanig dat in het model kan worden weergegeven dat de grond soms gelijktertijd verschillende functies vervult. De tweede uitbreiding is zo dat de invloed van transportkosten op de ruimtelijke structuur van de produktie kan worden weergegeven.

Hueting wijst erop dat de natuur verschillende functies vervult. Hij beschrijft dat de uitoefening van een functie soms ten koste gaat van die van de mogelijkheid een andere functie te vervullen. Hij spreekt van 'concurrentie van functies'. In de context van deze beschouwing is vooral de volgende vorm van concurrentie van functies van belang. Natuurbehoud draagt bij aan de welvaart. In het gestructureerde basismodel is de betreffende vorm van produktie ondergebracht in de agrarische sector. Immers, veel agrarische gebieden zijn van belang voor de instandhouding van de natuur en een uitbreiding van de geïndustrialiseerde landbouw in deze gebieden gaat vaak ten koste van deze functie van het land. Vanzelfsprekend staat de produktie van 'natuurgoederen', en die van agrarische goederen in het algemeen, eveneens onder druk van bepaalde vormen van industriële produktie.

Het aspect van het multifunctionele grondgebruik wordt ingevoegd in het model door, in eerste instantie, ruimte te bieden aan twee functies. Aldus ontstaat een 'bifunctioneel model'. Overeenkomstig dezelfde principes wordt ook een 'trifunctioneel' model geformuleerd. Verondersteld wordt dat, in principe, elke vorm van grondgebruik zich in elk produktieproces kan voordoen. Voorts wordt aangenomen dat de waarde van de grond niet wordt beïnvloed door voorschriften van de overheid, met betrekking tot het gebruik van gronden. In het model is de waarde van grond van een bepaalde kwaliteit dus gelijk in monofunctioneel en in multifunctioneel gebruik. Het model bevat land van verschillende kwaliteit en voorts diverse grondstoffen.

Problemen van zowel degeneratie van de natuur als die van technologie kunnen voorwerp zijn van regionaal-economische studie. Industrialisatie is een belangrijke oorzaak van natuurbederf, waarbij de locatie van bedrijven een belangrijke rol speelt.

Von Thünen introduceerde omstreeks 1850 het ruimtelijke gezichtspunt in de economische theorie. In diens concept is de produktie echter agrarisch van karakter. Launhardt bracht in 1885 een elementaire locatietheorie in wiskundige termen. Twee decennia nadien formuleerde Alfred Weber een meer algemene locatietheorie, welke, evenals de bovengenoemde theorieën, gebaseerd is op transportkosten. De theorie van Weber omvat ook de industrie. Voorts worden niet slechts de transportkosten van de producent naar de verbruiker in de beschouwing betrokken, maar ook die van grondstoffen. Aldus wordt rekening gehouden met het gewichtsverlies van deze grondstoffen in het produktieproces. Hotelling is een andere toonaangevende schrijver in deze traditie. In zijn model fungeren niet alleen afstanden, doch ook prijzen als variabelen.

Het basismodel wordt omgezet in een locatiemodel. Dit geschiedt op de volgende wijze. Het gebied in kwestie wordt verdeeld in regio's met dezelfde afmetingen. De afstanden tussen de regio's worden gemeten van centrum tot centrum. Ter vereenvoudiging van het model wordt verondersteld dat de consumptie in één regio is gelocaliseerd. Een aantal andere vereenvoudigende veronderstellingen wordt hieraan toegevoegd. Het model bevat twee verzamelingen van matrices die de mogelijke transport-afstanden weergeven. Op deze wijze kan het model in principe een groot aantal ruimtelijke constellaties weergeven, die echter resulteren in verschillende niveaus van sociale welvaart. Een rekenprogramma dient zo te zijn opgesteld dat alle mogelijkheden worden afgetast en de constellatie met het hoogste welvaartsniveau wordt geselecteerd.

De dynamiek van het systeem

De dynamisering van het statische model is zodanig, dat de verandering van de economische structuur continu wordt weergegeven. In het kader van de dynamiek van het systeem wordt, op een genuanceerde wijze, het karakter van de technische ontwikkeling aangegeven. De basis van de omschrijving wordt gevormd door de definiëring van Hicks, als volgt opgevat. Men neemt aan dat de produktiefunctie de homogene vorm heeft. Elke produktiefactor wordt voorzien van een 'coëfficiënt' in de exponentiële vorm. De coëfficiënt bestaat uit het grondtal van de natuurlijke logaritme met een aan de tijd gerelateerde grootheid als exponent. Neemt deze grootheid toe dan spreekt men van een factorbesparende ontwikkeling; neemt de grootheid af dan is er sprake van een ontsparende ontwikkeling, met betrekking tot de produktiefactor in kwestie.

Echter, in de karakterisering van Hicks blijft de mogelijke verandering van het aandeel van de betreffende produktiefactor in de categoriale inkomensverdeling buiten beschouwing. Deze maakt in het model wel deel uit van de definiëring. Wordt dit element in de overweging betrokken, dan wordt gesproken van een 'factorbezuinigende', respectievelijk een 'factorgebruikende' technische ontwikkeling. De diverse begrippen zijn aldus op elkaar afgesteld. De factor-bezuinigende of factorgebruikende ontwikkeling (factor-sparing versus factor-using developments) bestaat uit de volgende twee elementen. Het element van de factorbesparende of factoraantastende ontwikkeling (factor-saving versus factor-affecting development) en een element dat de invloed weergeeft van een verandering van het factoraandeel in de inkomensverdeling.

Op het punt van de intertemporele causaliteit valt het volgende op te merken. De druk van de geïndustrialiseerde produktie op de potenties van de natuur wordt weergegeven via de accumulatie van actieve verontreinigende stoffen in het milieu. Het gebruik en de emissie van grondstoffen wordt gezien als oorzaak van de degeneratie van de natuur. Om de oorzakelijkheid te formuleren worden de volgende begrippen omschreven: de emissiecoëfficiënt van een bepaalde grondstof in een bepaald produktieproces; de persistentiegraad, aangevend het deel van een bepaalde verontreiniging dat - in een bepaald tijdsbestek - niet door de natuur wordt geneutraliseerd; de milieu-effect-coëfficiënt, die het effect weergeeft van een bepaalde hoeveelheid in het milieu aanwezige actieve verontreiniging, van een bepaald soort, op de effectiviteit van land in een bepaald opzicht.

De technologische ontwikkeling moet gezien worden in het licht van de praktijk ten aanzien van de exploitatie van eindige natuurlijke voorraden. Gesteld kan worden dat, op een bepaald tijdstip, de welvaart wordt bepaald door de omvang van de invoer van grondstoffen in het produktieproces. De ontwikkeling van de welvaart, in de loop van de tijd, wordt eveneens bepaald door de exploitatiegraad van onvervangbare natuurlijke voorraden. Men kan zich een welvaarts-ontwikkeling voorstellen met een hoge exploitatiegraad en een ontwikkeling met een lage exploitatiegraad van uitputbare hulpbronnen. De laatstgenoemde ontwikkeling biedt relatieve voordelen na verloop van tijd. Bij de sociale keuze ten aanzien van de exploitatiegraad is de zogenoemde tijdsvoorkeur, voor consumptie in het heden, bepalend.

De afnemende functionaliteit van land

In vrijwel elke sector van agrarische produktie wordt de functionaliteit van de grond aangetast door het proces van industrialisatie, binnen zowel als buiten de landbouw. Dit betreft ook de instandhouding van de natuur. In de agrarische sector vindt dan ook systematisch verandering plaats. Zo wordt het oppervlak gecultiveerd land uitgebreid ten koste van het oppervlak ongecultiveerd land. Voorts wordt het oppervlak dat benut wordt voor geïndustrialiseerde vormen van agrarische produktie uitgebreid ten koste van het areaal dat gebruikt wordt voor traditionele vormen van grondgebruik. Deze tendenties worden in het analytische schema gevoegd.

De westerse geschiedenis is gekenmerkt door een voortgaande omzetting van natuurlijke gronden in landerijen. Het beeld is echter vrij gecompliceerd. Soms zijn woeste gronden omgezet in bossen, die benut konden worden. Later zijn veel bossen omgezet in landbouwgronden. In veel westerse landen zijn deze omzettingen tot een eind gekomen. Hiervoor zijn verschillende oorzaken. Zo zijn de mogelijkheden voor het benutten van land voor agrarische doelen grotendeels uitgeput. Een andere oorzaak is dat de sociale waardering van woeste gronden en bossen drastisch is verhoogd, en men inziet dat een voortgaande uitbreiding van het areaal met een typisch agrarische bestemming het functioneren van de bestaande natuurlijke ecosystemen bedreigt.

Daar een waardering van de grond op basis van de voorkeuren van de eigenaars en de gebruikers van de grond niet altijd in overeenstemming is met de genoemde sociale waardering, is in de meeste westerse landen de ontginning van gronden ingeperkt door voorschriften van de overheid, met betrekking tot de bestemming van de grond. Dit houdt in dat er geen marktmechanisme is dat het inkomen uit de grond gelijk maakt aan de volledige sociale waardering van de beschermde stukken natuur. De opbrengsten uit het bosbedrijf zijn in veel gevallen zelfs niet voldoende om de kosten van de instandhouding van het bos te dekken.

Richt men de aandacht op structurele veranderingen in het agrarische gebied, dan vallen drie vormen van geïndustrialiseerde landbouw te onderscheiden: monocultuur, bio-industrie en glastuinbouw. Men kan zich de westerse landbouw niet voorstellen zonder deze typische produktievormen. De uitdaging is niet deze produktievormen radicaal te elimineren, maar de schadelijke effecten ervan drastisch te verminderen. Tevens geldt de vraag, hoever moet men gaan bij de bestemming van landerijen voor industriële landbouw? Wat zijn de gevolgen van deze ontwikkeling voor de sociale welvaart, wanneer men rekening houdt met milieu-effecten?

De 'traditionele' landbouw vervult een bijzondere functie bij de instandhouding van natuurlijke ecosystemen, welke functie wordt gefrusteerd als in de betreffende gebieden de landbouw op industriële wijze wordt uitgeoefend. Uit een economisch oogpunt is deze functie verborgen. In sommige gebieden hanteert de overheid het instrument van planologische voorschriften, om tegemoet te komen aan de sociale behoeften. Uiteengezet wordt dat op deze wijze het euvel slechts ten dele wordt verholpen.

Het ontwikkelingsbeeld

De degeneratie van de natuur, zijnde de vermindering van de kwaliteit van het leefmilieu en de uitputting van natuurlijke voorraden, dient te worden geplaatst in de context van de economische ontwikkeling. Twee tegengestelde visies op dit ontwikkelingsproces worden onder woorden gebracht. Daarna worden de twee visies geïntegreerd in één analyse.

Economische ontwikkeling kan op verschillende wijzen worden weergegeven, naar gelang van de causale factoren die worden belicht. Dit is ook van toepassing op het proces van industrialisatie van de westerse wereld. Twee tegenovergestelde ideeën omtrent de oorzaak van de maatschappelijke ontwikkeling worden hier onder woorden gebracht.

De economische wetenschap ontstond in het filosofische klimaat van de Verlichting, een manier van denken die een blijvend stempel op de economiebeoefening heeft gedrukt. Speciaal voor de milieu-economie heeft dit het voordeel dat de verklaring van het functioneren van de natuur, op de wijze van de natuurwetenschap, gemakkelijk in het denken kunnen worden ingevoegd. Een nadelige bijkomstigheid is, dat het economisch denken gemakkelijk kan functioneren als klankbord voor aprioristisch optimisme omtrent de economische ontwikkeling in de toekomst. Immers, het welvaartsoptimisme dat lange tijd typerend is geweest voor het economisch denken, is gebaseerd op het verlichte denken. In deze filosofie is het steeds verder doordringen van de 'rede' in het denken over de gewenste organisatie van de samenleving, de stuwende kracht in de maatschappelijke ontwikkeling.

Deze denkwijze bevat de gedachte dat de spectaculaire ecomische ontwikkeling van de laatste eeuwen geheel valt toe te schrijven aan activiteiten van de menselijke geest die, bouwend op de vindingen van vorige generaties, tot steeds grotere prestaties in staat is. In deze visie is het gebruik van grondstoffen een facet van de relatie tussen mens en natuur, waarbij de mens in staat is de natuur steeds intensiever te benutten. Is een natuurlijke hulpbron uitgeput, dan richt de aandacht zich op andere mogelijkheden van de natuur. Steeds dienen zich nieuwe mogelijkheden aan, in het licht van steeds toenemende kennis. Waarom zou men bezorgd zijn over leefomstandigheden in de toekomst, bij zoveel bewijzen van steeds toenemend technisch en organisatorisch vernuft?

De negentiende-eeuwse Romantiek fungeerde als voedingsbodem voor wijzen van economsch denken waarin, in de voetsporen van Malthus en de Fysiocraten, niet de menselijke bekwaamheid maar de mogelijkheden van de natuur werden beschouwd als de belangrijkste oorzaken van welvaart. Zo is de benutting van de natuur een belangrijk onderwerp in het denken van de Historische school. De volgende visie op het proces van industrialisatie kan worden geplaatst tegen deze achtergrond.

De mens maakt deel uit van een natuurlijk systeem, dat hem een speciale mogelijkheid verschaft om in zijn behoeften te voorzien. Hij heeft de mogelijkheid zijn mogelijkheden zo te gebruiken dat de natuur onder invloed van de produktie degenereert. In vroeger tijden werden grote delen van de aarde onvruchtbaar door ontbossing en verzilting. In de industriële produktie vindt een dergelijk proces van uitputting van de natuur plaats, doch op een veel grotere schaal. Teneinde een klein deel van de wereldbevolking een ongekend hoge levensstandaard te verschaffen worden natuurlijke voorraden op grote schaal verbruikt. Deze voorraden zouden echter mede ten dienste moeten staan van andere delen van de wereldbevolking en aan toekomstige generaties, die echter wel de lasten van de milieuverontreiniging hebben te dragen. Wie zou zich geen zorgen maken omtrent de toekomst, bij zoveel bewijzen van wanbeleid?

In deze analytische studie zijn elk van de twee bovenstaande visies vertegenwoordigd. Het economische aspect van de mogelijkheden van de menselijke geest wordt in deze context aangeduid als technologie. De vermindering van de potenties van de natuur - door verbruik van natuurlijke voorraden, door vermindering van de vruchtbaarheid van de grond en door de vermindering van de kwaliteit van het leefmilieu in het algemeen - wordt aangeduid als uitputting van de natuur. De vraag welke tendentie het beeld beheerst, wordt niet op aprioristische wijze beantwoord. Volstaan wordt met het verschaffen van een denkschema waarin beide ideeën zijn ondergebracht.

In dit verband wordt ook een plaats ingeruimd voor het aspect bevolkingsgroei. Toegegeven moet worden dat er situaties zijn waarin bevolkingsgroei een positieve invloed heeft op de welvaart van de gemeenschap, bijvoorbeeld via een positieve invloed op het technisch kunnen. Er zijn echter ook talloze situaties waarin het effect van de bevolkingsgroei op de welvaart negatief is. Dat zijn die situaties waarin de aan bevolkingsgroei gerelateerde produktiestijging achter blijft bij de daaraan eveneens gerelateerde toename van de behoeften.

Internalisering van land

Uit een oogpunt van efficiëntie is het nodig dat de prestaties in het economische circuit worden beloond overeenkomstig hun betekenis voor de sociale welvaart. Is dat niet het geval, dan dient de wijze van honorering van produktiefactoren te worden aangepast. Dit principe wordt uitgewerkt voor het eerder beschreven verschijnsel van de verborgen functie van land.

Planologische beslissingen zijn gericht op de bestemming van land en tasten daarom vaak de waarde van de grond aan. Men kan stellen dat planologische voorschriften enerzijds het welvaartstheoretische mechanisme in de samenleving ondersteunen, doch deze anderzijds frustreren. Hierbij domineert het eerstgenoemde aspect. Een aantal planologische voorschriften corrigeert de omstandigheid dat enkele belangrijke sociale doelstellingen niet kunnen worden bereikt, omdat sommige welvaartseffecten niet in het economisch mechanisme zijn ingevoegd. Als zodanig is de planologie een onmisbaar instrument in de welvaartspolitiek. Echter, het beeld van het hiervoor gepresenteerde gestructureerde model wordt gewijzigd door de planologische ingrepen. De prijs hiervan is een verlies aan welvaart, als aangegeven door het beschreven model.

Planologie heeft, gezien uit een welvaartstheoretisch oogpunt, echter ook een bedenkelijk aspect. Immers, de inkomens van de eigenaars en de gebruikers van het land waarvan de bestemming is veranderd door planologische voorschriften, zijn nog steeds gebaseerd op het oorspronkelijke schema van typisch economische activiteiten. Er is dus een discrepantie tussen de brede fundatie van het systeem van planologische voorschriften en de smalle typisch economische basis van het beloningsschema van de functies van land.

Internalisering van de verborgen functie van de grond, in het economische systeem van prestaties en beloningen, is dienstbaar aan de efficiëntie in het maatschappelijke verkeer. De vraag dient zich evenwel aan, welke criteria moeten gelden bij de vaststelling van een subsidie aan de eigenaar of de gebruiker van de grond. Het antwoord kan niet zijn dat de houder van de grond een uitkering krijgt overeenkomstig de volledige sociale waarde van het betreffende stuk natuur. Hiervoor is geen morele basis en bovendien zou een dergelijke uitkering in de praktijk onmogelijk zijn.

Het volgende principe past beter in de filosofie van de welvaartseconomie. Een produktiefactor, ook als deze een positief extern effect genereert, dient zo te worden beloond dat het aanbod in stand blijft. Dit principe, hoewel nog vaag geformuleerd, is ook van toepassing op de beloning van de factor natuur, voor zover de betreffende functie wordt uitgeoefend met menselijke hulp. In dit verband kunnen twee situaties worden onderscheiden. Er is de situatie waarin de houder van de grond wettelijk verplicht is bepaalde taken, gericht op natuurbehoud, uit te oefenen. De andere situatie is die waarin het slechts door de gemeenschap wordt 'geapprecieerd' dat de houders van de grond het land op een bepaalde manier gebruiken.

Een voorbeeld van de eerste situatie is de boseigenaar, die wettelijk verplicht is om na kaalkap opnieuw bos in te planten. Wanneer het evident is dat de houtprijzen te laag zijn om de kosten van herbebossing te dekken, dan is een uitkering gerechtvaardigd. Een voorbeeld van de tweede situatie is het geval waarin de gemeenschap, vertegenwoordigd door de overheid, er prijs op stelt dat in een bepaalde streek de landbouw op een traditionele wijze wordt uitgeoefend, om te voorkomen dat enerzijds het landschap verwildert en anderzijds de landbouw op industriële wijze wordt uitgeoefend. Ook in dit geval is, uit een welvaartstheoretisch oogpunt, een subsidie op haar plaats.

De omvang van de subsidie bepaalt niet alleen de effectiviteit van dit instrument op de korte termijn, maar ook de invloed op de natuur op de lange termijn. Een lage honorering zal slechts bevorderen dat de aanwezige agrarische beroepsbevolking de activiteiten nog enige tijd voortzet. Een voldoende hoge honorering zal echter tevens een verjonging van de staf en de invoering van nieuwe, aangepaste technieken bevorderen.

Wat betreft de financiering van de genoemde subsidies, die slechts een klein deel zouden vormen van de totale uitgaven voor natuurbehoud, valt het volgende op te merken. Het is een oud politiek principe om de kosten van de overheid waar mogelijk te dekken uit royalties. Het principe zou ook in dit geval kunnen worden toegepast. Betalingen aan de houders van de grond ter beloning van de verborgen functie van de natuur, kunnen op twee manieren worden geëffectueerd. De uitkeringen kunnen luiden per werkkracht, die op duidelijk omschreven wijze werkzaam is in dienst van het natuurbehoud. Een andere mogelijkheid is een betaling per specifieke prestatie in dit vlak.

Politicologie van de milieu-technologie

Een belangrijke overweging voor de technologie politiek is, dat de welvaartsverhoging die samenhangt met een vergroting van de potenties van de produktiefactoren twee aspecten heeft. Het ene aspect is het factor-besparende element, in Hicksiaanse zin, van de technologische verandering. Het andere aspect is de verandering van de substitueerbaarheid met andere produktiefactoren, die een verandering van het factoraandeel van de factoren in het inkomen inhoudt. Men moet zich echter realiseren dat, als men het gebeuren modelmatig weergeeft, de betreffende variabelen niet onafhankelijk variëren. Niettemin wordt een poging gedaan de twee facetten van technologische ontwikkeling te analyseren vanuit het gezichtspunt van natuurbehoud.

De factor-besparende tendentie is de belangrijkste karaktertrek van elke technologische ontwikkeling. Zo houdt elke verbetering van het gebruik van de grond een directe toename in van de capaciteit van de grond. Een vermindering van de milieuvervuiling kan op deze capaciteit een indirecte positieve invloed hebben. In beide gevallen kan worden gesproken van een land-besparende technische ontwikkeling.

De substitutie-tendentie speelt echter tevens een belangrijke rol. De vervanging van een produktiefactor uit de categorie 'natuur' door een minder schaarse factor uit deze categorie kan worden beschouwd als technologische vooruitgang, uit een milieu-oogpunt beschouwd. Het laatste geldt ook als de vinding een vervanging inhoudt van grondstoffen door arbeid. Bij veel vindingen is echter het omgekeerde het geval. Hoewel hierdoor de welvaart tijdelijk kan stijgen, kan hier niet worden gesproken van technologische 'vooruitgang' uit het standpunt van natuurbehoud. Vanuit dit standpunt is het dan ook wenselijk dat de lonen relatief laag zijn.

Men ziet zich gesteld tegenover de vraag, wat de invloed is van het marktmechanisme en het institutionele beslissingskader in het algemeen, op de ontwikkeling van de milieu-technologie. Deze vraag wordt toegespitst op drie facetten: het realiteitsgehalte van de welvaartstheorie op dit punt, de complicaties op het gebied van de prijs en schaarste van produktiefactoren uit de categorie 'natuur' en het probleem van de verhouding tussen natuur en arbeid in het economische proces.

De dreigende milieucrisis maakt een drastische milieupolitiek noodzakelijk. Deze politiek heeft een verschillend karakter, naar gelang van de termijn waarop deze politiek is georiënteerd. Het korte- termijn-scenario omvat een gerichte herstructurering van de industrie. Het middellange-termijn-scenario heeft betrekking op een stimulering van de milieu-technologie. Het lange-termijn-scenario is vooral gericht op institutionele aanpassingen.

Natuurbehoud in de collectieve besluitvorming

Hoe kan men, denkend in welvaartstheoretische termen, de overweging van natuurbehoud plaatsen in de collectieve besluitvorming? Met een beschrijving van enkele principes die op dit punt gelden wordt de studie afgesloten.

De basis van de beschouwing wordt gevormd door een zodanige analyse van de sociale welvaartsfunctie, dat de welvaart in eerste instantie wordt bepaald door twee factoren: de waarde van de produktie, voorzover typische milieugoederen buiten beschouwing blijven, en een index van de kwaliteit van het milieu. Elk van deze twee factoren wordt bepaald door een partiële welvaartsfunctie. De index van milieukwaliteit is in deze analyse dus geen louter technisch gegeven, maar bevat ook het element 'sociale waardering'. De twee genoemde welvaartsfactoren zijn ook opgenomen in een produktiemogelijkhedenfunctie.

Men kan spreken van 'complementaire' milieupolitiek als de overheid inspeelt op de behoefte aan 'natuurgoederen' door deze zelf te produceren. Voorbeelden zijn: de constructie van rioleringen en de uitvoering van projecten ter bescherming van het landschap, de flora en de fauna. Uitgebeeld wordt dat, dank zij dit complementaire milieubeleid, de sociale welvaart op een hoger niveau komt.

Van een 'interveniërend' milieubeleid kan men spreken als de overheid, ter bescherming van de natuur, ingrijpt in de omstandigheden waarin de beslissingen van producenten en consumenten tot stand komen. In deze context wordt de idee van het 'prisoner's dilemma' geplaatst. Ook in het kader van dit facet van de milieupolitiek wordt uitgebeeld dat op deze wijze de welvaart wordt vergroot.

Tenslotte wordt aangegeven dat het complementaire en het interveniërende beleid in de milieupolitiek twee componenten zijn, die gericht zijn op één globale doelstelling: de realisering van de optimale existentie van mens en milieu. Tenslotte wordt aangegeven dat deze vorm van welvaartstheoretisch denken zich laat invoegen in het systeemtheoretische denken.

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