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Construction raw materials policy and supply practices in Northwestern Europe

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ABSTRACT

The present contribution is an inventory of the construction raw materials policy and supply practices in the Netherlands, Belgium, North Rhine-Westphalia, Lower Saxony, Great Britain, Norway and Denmark. The work has been commissioned by the Dutch government in order to benchmark its domestic provision and the governing mineral planning policy.
About 666 Mt of aggregates, 79 Mt of limestone, 32 Mt of clay and 13 Mt of silica sand have been extracted in the studied countries in 2000. About 74 Mt (9%) of the extracted materials were traded internationally, mainly within the study area. The area as a whole is approximately self-supporting. Norway, Scotland and North Rhine-Westphalia are net exporters of aggregates. Belgium and the Netherlands are net importing countries. This is related to limited reserves; in the case of the Netherlands it is also related to a restrictive permission policy.
The mineral planning policies in the study area all address sustainability, and pursue, e.g., the minimization of extraction, an economical materials use and recycling. However, the extent to which this is accomplished varies considerably, due to differences in factors such as the building tradition, population density, the socio-economical situation and geology.

KEY WORDS

Aggregates, Belgium, building materials, clay, crushed rock, construction materials, Denmark, Europe, Germany, gravel, Great Britain, limestone, Lower Saxony, Netherlands, North Rhine-Westphalia, Norway, sand, silica sand.

Introduction

Building, construction and several industrial processes require large amounts of natural or crushed aggregates, limestone and clay. In the past, communities exploited local resources, which is clearly reflected in historical architecture and crafts products. Nowadays, raw materials are traded internationally and shipped over fairly large distances.
In accordance with the trend of internationalization, and because of a relatively big dependency on imports, the Dutch Ministry of Transport, Public Works and Water Management has commissioned an inventory of the provision of sand, gravel, crushed rock, limestone, silica sand, clay and fill material in northwestern Europe. The results of the study will be used to benchmark the Dutch provision and governing policy. The studied materials are the principal minerals worked in the Netherlands. The study area consists of the Netherlands, and the main countries it imports from or exports to: Belgium, Germany (North Rhine-Westphalia and Lower Saxony), UK (England, Wales and Scotland), Norway and Denmark (Fig. 1).
The inventory has resulted in six reports prepared by regional specialists (Broekmans & Neeb, 2003; Desmyter *et al*., 2003; Harrison *et al*., 2003; Knoll & Kramer, 2003; Koopmans *et al*., 2003; Nielsen *et al*., 2003). Topics addressed are resources, their exploitation, alternative materials, trans-boundary trade, and the governing legislations and policies (see also Ike & Voogd, 1987; Grantham *et al*., 1995). The present paper summarizes the regional reports and presents comparisons and considerations on the international level, with emphasis on the role of the Netherlands.

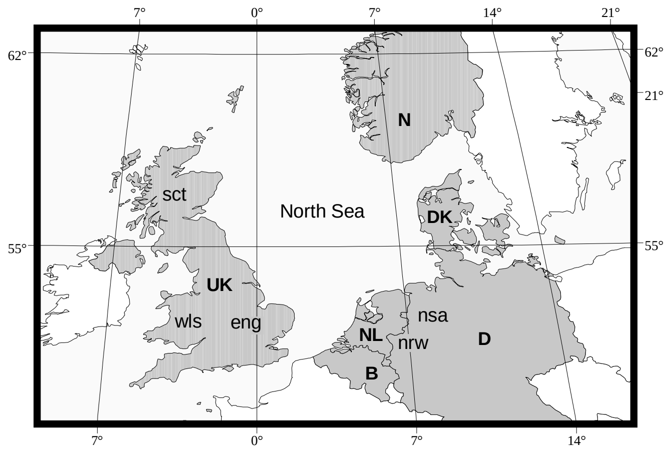

Fig. 1. The study area: the Netherlands (NL), Belgium (B), Germany (D), North Rhine-Westphalia (nrw), Lower Saxony (nsa), Denmark (DK), the United Kingdom (UK), England (eng), Wales (wls), Scotland (sct) and Norway (N).

Data

All data used in this study can be obtained from the internet (www.international.bouwgrondstoffen.info). They have

Table 1. Definitions of resources and commodities

Material	Description
Aggregates	Sand, gravel, crushed rock and secondary materials, used in construction and the building materials industry for its granularity (as opposed to, e.g., silica sand, which is used for its chemical properties).
Asphalt waste	Bitumen-coated material derived from pavements (secondary material).
Blast furnace slag	Slag from the production of iron from iron ore (secondary material).
Clay	Fine grained cohesive material used for construction (dike building, the covering of land fills, etc.), and fireclay used in the building materials industry (for the production of bricks, pipes, tiles, etc.). Clay for fine ceramic applications, such as china clay and ball clay, is excluded.
Coal bottom ash	Coarse ash from the burning chamber of coal-fired power stations (secondary material).
Coal fly ash	Ash precipitated from the off-gases of coal-fired power stations (secondary material).
Colliery spoil	Waste rock from the mining and processing of coal (secondary material).
Construction and demolition waste	Any material arising from the processes of construction and demolition (secondary material).
Crushed rock	Any sedimentary rock (limestone, sandstone, etc.) or crystalline rock (granite, porphyry, etc.) used for aggregates production.
Fill material	Any aggregate or clay for fill uses.
Gravel	Coarse natural aggregate used for concreting, drainage media, etc.
Limestone for industrial use	Carbonate rock (limestone, dolomite and chalk) for non-aggregate uses, i.e. for cement clinker production, as a flux in the metal and glass industries, in the chemical industry, in animal fodder, etc.
MSWI bottom ash	Coarse ash derived from the burning chamber in municipal solid waste incinerators (secondary material).
MSWI fly ash	Ash precipitated from the off-gases in municipal solid waste incinerators (secondary material).
Primary materials	Natural (quarried) materials.
Sand	Concreting sand, masonry sand and (usually coarse) sands for other purposes which require specific granular compositions. The term excludes sand used as fill material and for non-aggregate purposes (i.e. silica sand).
Secondary materials	Earthy and stony waste materials and industrial by-products, used as alternatives to the primary materials considered in this study.
Silica sand	Sand used as a quartz resource, used for the production of, e.g., glass, water glass, zeolites, carborundum, ceramics, and in foundries.
Steel slag	Slag from the production of steel from iron and scrap iron / steel (secondary material).

been gathered from official statistics and publications, and from interviews with government and business community representatives. For an account per country, the reader is referred to the regional reports. Note that:

- Quarry products are usually either defined in geological terms, or according to the demands for their applications. These terminologies may overlap, and tend to vary per country. In this study, data have been gathered using a single set of definitions (Table 1) and a fixed fact sheet format.
- Some of the used data sets lacked the requested amount of detail. If so, combined figures are presented (in categories such as ‘sand and gravel’ or ‘gravel and crushed rock’).
- The statistical quality of the data varies per country.
- Some statistics are not available for individual states. In such cases, national data are used for international comparisons (i.e. German in stead of North Rhine-Westphalian and Lower Saxon data, or UK in stead of Scottish, English or Welsh data).
- The Belgian Flemish and Walloon regions are quite different socio-economically, geographically, and in terms of their resources. In most cases, however, Belgian data do not allow for a distinction between the two.
- UK data do not allow for a distinction between England and Wales.
- The combined data set allows for general inferences only.

Introduction to the study area

The Netherlands

In 2000, the Netherlands produced about 88 Mt of (fine) filling sand (36 Mt of which marine dredged), 21 Mt of (coarse) sand, 6.6 Mt of gravel, 4.0 Mt of clay and 1.5 Mt of limestone for industrial use. About 15 Mt of aggregates were exported, 34 Mt were imported (Fig. 2).

Dutch mineral planning policy aims at a sustainable exploitation of surface mineral resources to meet the demand for construction and building materials, at an economical use, and maximum use of renewable and secondary materials (recyclable industrial by-products and waste materials; Anonymous, 2001a). The national government provides mineral planning guidance and is the permission authority for the state waters. The provinces address mineral planning in regional plans and are the permission authority for the land area.

In the past decades, land extraction has met with a growing societal resistance. As a consequence, provincial administrations have become increasingly reluctant to grant extraction permits. This especially applies to large-scale coarse sand and gravel extractions which, for geological reasons, are operational or considered in the southeastern half of the country, while a large part of the demand is generated elsewhere. In order to sustain the aggregates supply, assignments (‘taakstellingen’), i.e. amounts of quarry products for which permits are to be granted, have been negotiated between national and provincial rulers. For concreting and masonry sand, the assignments up till 2008 add up to about 75% of the expected national demand. The production of gravel, which only occurs in the south-easternmost part of the country, has been allowed to become reduced to a level of regional self-supply.

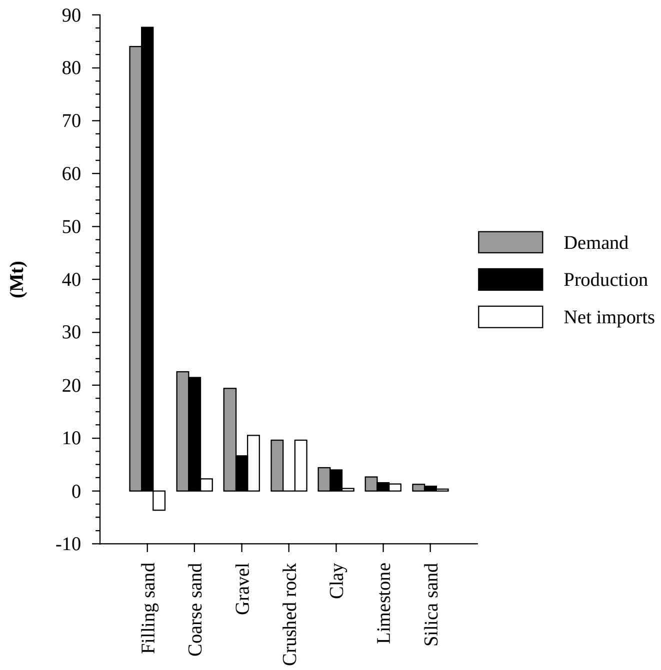

Fig. 2. The provision of aggregates, clay, limestone and silica sand in the Netherlands in 2000 (data from Koopmans et al., 2003; Van der Meulen et al., in press).

The policy to stimulate the utilization of secondary materials, by means of product quality control on the one hand, and the taxation and banning of landfilling with recyclable materials on the other, has been quite successful. Their use rose from ~7 Mt/a in the early 1980s to 33 Mt in 2000; their share in the total provision rose from 6 to 15%. The use of renewable materials, especially timber, is stimulated by demonstration and research projects carried out or commissioned by the government, in cooperation with the timber and building industries. The current share of timber-framed and timber-built houses is about 8%/a. The government has also issued guidelines for sustainable building.

At present, the national government is considering a lesser role in mineral planning. The regulatory system of provincial assignments for concreting and masonry sand will most probably be abandoned; as a result of this, the home production may fall back in the foreseeable future.

Germany (North Rhine-Westphalia and Lower Saxony)

In 2000, North Rhine-Westphalia produced about 81 Mt of sand and gravel, 43 Mt of crushed rock, 22 Mt of limestone for industrial use, 7.1 Mt of clay and 3.3 Mt of silica sand (Fig. 3). Lower Saxony produced 48 Mt of sand and gravel, 12 Mt of crushed rock, 5.5 Mt of limestone for industrial use, 1.5 Mt of silica sand, 2.6 Mt of clay and 1.5 Mt of silica sand (Fig. 4). Germany exported about 19 Mt of sand, gravel and crushed rock to Belgium and the Netherlands, mainly from North Rhine-Westphalia, and in the case of the Netherlands primarily by shipping down the Rhine. About 20 Mt of aggregates were imported, the larger part from France and Norway.

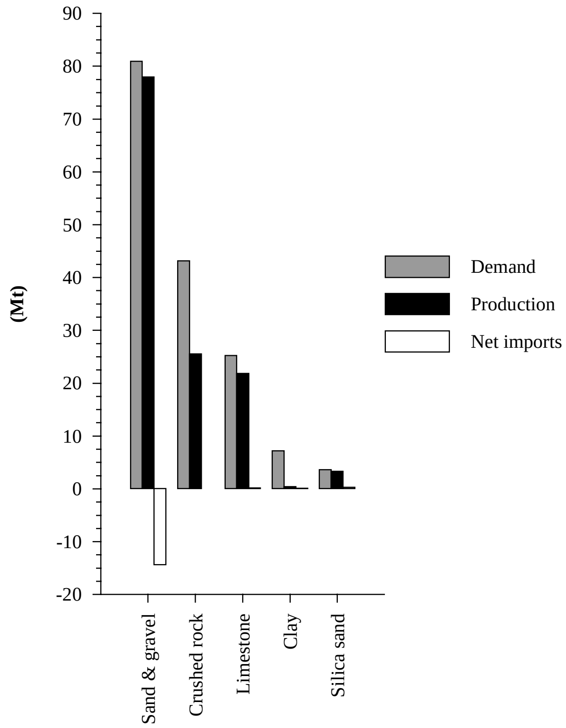

Fig. 3. The provision of aggregates, limestone for industrial use, clay and silica sand in North Rhine-Westphalia in 2000 (data from Knoll & Kramer, 2003). Sand and gravel are not monitored individually; data for fill material are not available. Inconsistencies — demand should approximately equal the sum of production and net imports — are due to limitations of the data sets used.

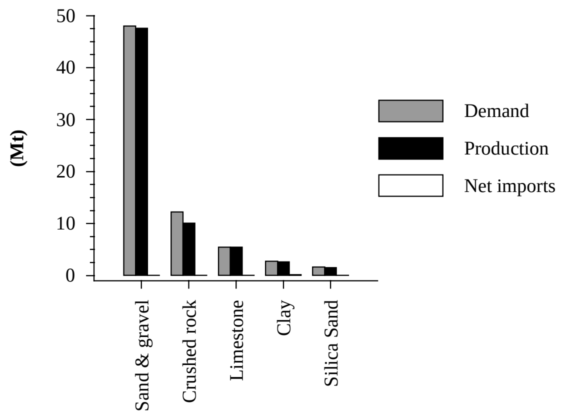

Fig. 4. The provision of aggregates, limestone, clay and silica sand in Lower Saxony in 2000 (data from Knoll & Kramer, 2003). Sand and gravel are not monitored individually; data for fill material are not available.

Germany used about 75 Mt of secondary materials for building and construction, which is about 10% of the total materials use (disregarding fill material, for which no data are available). The use of renewable raw materials for building and construction is limited to timber; ~12% of the houses built yearly are timber-built or timber-framed.

The German federal government is responsible for planning guidance for silica sand, some types of clay and various non-building minerals not considered in this study. It also provides policies for sustainability, environmental protec-

tion, waste management and recycling (Anonymous, 2001b). In accordance with these policies, the federal government and the building industry have reached an agreement aimed at increasing the recycling ratio for building materials.
Mineral planning guidance for building and construction raw materials is the responsibility of state governments. Shared topics are the economical use of natural resources, promotion of the use of secondary materials and renewable materials, minimization of transport, a decrease of wet extraction and a reduction of extraction in areas of nature interest. The Lower Saxon government has defined areas which are either reserved or to be considered for future extraction (Anonymous, 1994). The North Rhine-Westphalian government has formulated intentions for mineral extraction, without defining spatial specifications (Anonymous, 1995). Permitted reserves are to last for 25 years at all times.
German extraction permission authorities are regional governmental tiers. In Lower Saxony and North Rhine-Westphalia, these are the so called 'Landkreis' and 'Regierungsbezirk' authorities, respectively, which operate within the policy framework provided by the state governments.

Norway

In 2001, Norway produced about 52 Mt of aggregates (crushed rock, sand and gravel) for use in building and construction (Fig. 5). About 10 Mt of crushed rock were exported, mainly to Germany, Denmark and the UK. The variety of available rock types enables the production of a wide range of crushed rock qualities. This includes crushed quartzite which is used as a quartz resource (as silica sand in the other countries). About 1.3 Mt of this material was produced, almost entirely for exports. Norway produced over 6.3 Mt of limestone for industrial use, 2.0 Mt of which were exported. Clay is produced in limited amounts (44 kt in 2000) for home production of structural ceramic products. These products (rather than the raw material) are also imported, mainly from Denmark.

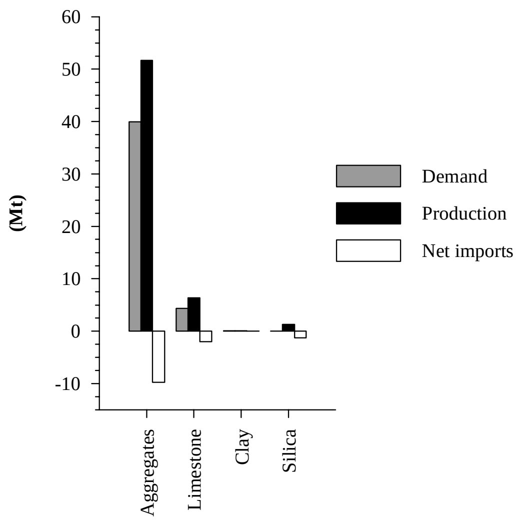

Fig. 5. The provision of aggregates, limestone, clay and silica (crushed quartzite) in Norway in 2001 (data from Broekmans & Neeb, 2003). Aggregates are not monitored individually; data for fill material are not available.

The only secondary material for which data are available is construction and demolition waste. Production in 2001 amounted to about 1.5 Mt. Recycling is estimated at 11%, which is low compared to the other studied countries. The use of renewable raw materials for building and construction is limited to timber. Over 4.5 million m³/a are used in construction; about 62% of all houses built in 2001 are timber-framed or timber-built: this is the highest share in the study area. A downward trend is predicted because of an increasing share of high-rise building.
Raw materials policy in Norway is characterized by general national planning guidelines and regulations, implemented by local authorities (counties and municipalities) which have a large degree of autonomy (Dagestad, 1999). Economical considerations and employment generated by the mineral extraction industry play an important role in planning decisions. Both national and local authorities support production for exports of aggregates, and consider the development of coastal superquarries for this sole purpose.
Due to the combination of large building and construction materials resources and a low population density, waste recycling is hardly an issue. Policy aims to increase the utilization of secondary materials in building and construction. In conjunction with this goal, guidelines for bound applications are under development. The use of renewable raw materials, i.e. timber, is driven by tradition and local availability, and not enforced by government policy.

Belgium

In 2000, Belgium produced about 38 Mt of crushed rock and gravel, 10 Mt of sand (3 Mt of which marine dredged), 10 Mt of limestone, 5.8 Mt of clay, 4.0 Mt of silica sand and 3.6 Mt of fill material (mainly fine sand; Fig. 6). Belgium is a net exporter of crushed rock and gravel (7.9 Mt in 2000, mainly to the Netherlands and France) and a net importer of sand (about 15 Mt, from the Netherlands, Germany and the UK).

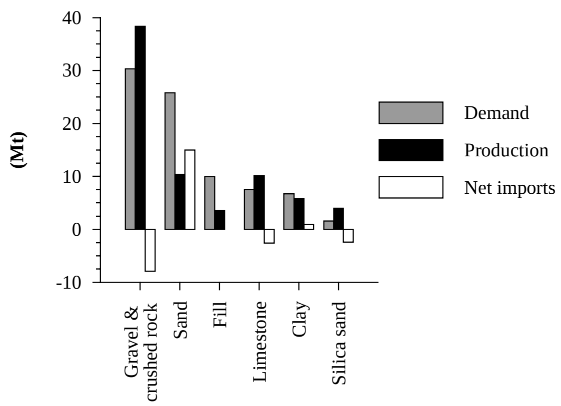

Fig. 6. The provision of aggregates, limestone, clay and silica sand in Belgium in 2000 (data from Desmyter et al., 2003).

Belgium uses various secondary materials, such as construction and demolition waste, asphalt waste, industrial slag and ashes. The total production in 2000 was about 11 Mt; the overall recycling percentage was about 75%. The share of secondary materials in the total provision was about 9%. The use of renewable raw materials for building and construction is limited to timber. The percentage of timber-built

and timber-framed houses built yearly is estimated between 8 and 12%.
Belgian policy on raw materials and mineral planning is the responsibility of the regional governments. The federal government only provides policy on related environmental issues. In the Flemish region, provinces and municipal administrations are extraction permission authorities for large and small exploitations, respectively. In the Walloon region, extractions of any size are permitted by the municipalities. Sea bed extraction permits are issued by the federal government. In the whole of Belgium, the building and construction raw materials provision is essentially left to the market. In the Flemish Region, the so called gravel decree ('grinddecreet'; Anonymous, 1993) provides for the gradual reduction of gravel extraction, and an extraction stop in 2006. The Flemish government is currently redesigning its mineral planning policy. A new decree aims at a sustainable exploitation of mineral reserves (Anonymous, 2002a). It introduces a mineral planning horizon of 25 years, stimulates the utilization of secondary materials, and addresses the environmental hygiene of minerals and restoration and aftercare of extraction sites. The Walloon regional government is also reconsidering its mineral planning policy, and aims to increase the export levels of quarry products for economical reasons (Anonymous, 2002b). Views on sustainability, especially concerning the utilization of secondary materials, are similar to those in Flanders.

Denmark

In 2000, Denmark produced about 58 Mt of aggregates (mainly sand and gravel; 12 Mt of which marine dredged), 5.7 Mt of limestone, 1.7 Mt of clay and 0.8 Mt of silica sand (Fig. 7). On average, it is a self-supporting country, about 3 Mt of (mainly) aggregates are imported and 2 Mt exported. The most important import category is crushed rock from Norway.

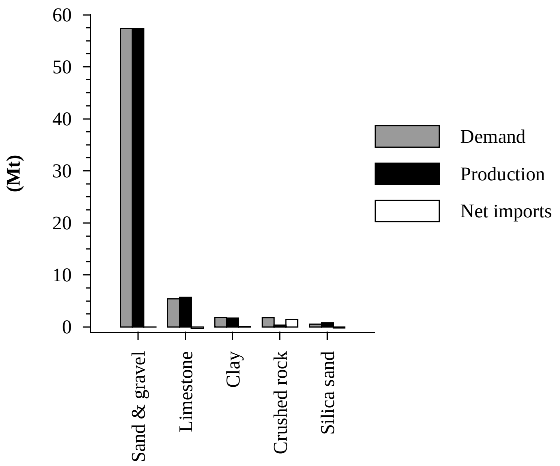

Fig. 7. The provision of aggregates, limestone, clay and silica sand in Denmark in 2000 (data from Nielsen et al. 2003). Sand and gravel are not monitored individually, data for fill material are not available.

About 3.8 Mt of construction and demolition waste, asphalt waste and power plant residues have been used as secondary materials in 2000, which is about 5% in the total provision. Recycling percentages, as far as they are known, are high: about 90% for construction, demolition and asphalt waste, and 80% for power plant residues. The use of renewable raw materials for building and construction is limited to timber. Almost 10% of the houses built yearly are timber-built or timber-framed.
Danish mineral planning guidance is the responsibility of the national government (Anonymous, 1996a, 1997, 2000a). Important policy topics are the economical and sustainable use of natural resources, environmental and geographical aspects (water supply, archaeological and geological interests, landscape protection, agriculture, forestry, etc.), which have to be taken into account in planning decisions (Anonymous, 1999). Within these boundary conditions, the raw materials provision is largely left to the market. Extraction permits have to be obtained from counties, which have their own mineral planning policies.
Policy goals for secondary materials are to achieve 90% recycling of construction and demolition waste, screening and separate collection of environmentally damaging waste fractions and to increase environmental planning in the building process (Anonymous, 1998, 2000a). There are no quantitative goals for the use of renewable materials, but it is supported by the general policy goal on sustainability.

England/Wales and Scotland

In 2000, England and Wales produced about 77 Mt of sand and gravel (23 Mt of which marine dredged), 62 Mt of crushed rock, 54 Mt of fill material, 10 Mt of clay and 3.7 Mt of silica sand (Fig. 8). An unknown but substantial amount of limestone was produced (the total production in Great Britain was about 28 Mt). Over 7 Mt of marine dredged sand and gravel were exported, mainly to the Netherlands (4 Mt), Belgium (2,5 Mt) and France (1 Mt). Scotland produced about 15 Mt of crushed rock, 12 Mt of fill material, 7.0 Mt of sand and gravel, 0.5 Mt of clay, 0.5 Mt of silica sand, and an unknown quantity of limestone (Fig. 9). 4.6 Mt of crushed rock were exported, mainly to England (2.2 Mt), Germany (1 Mt) and the Netherlands (1 Mt).

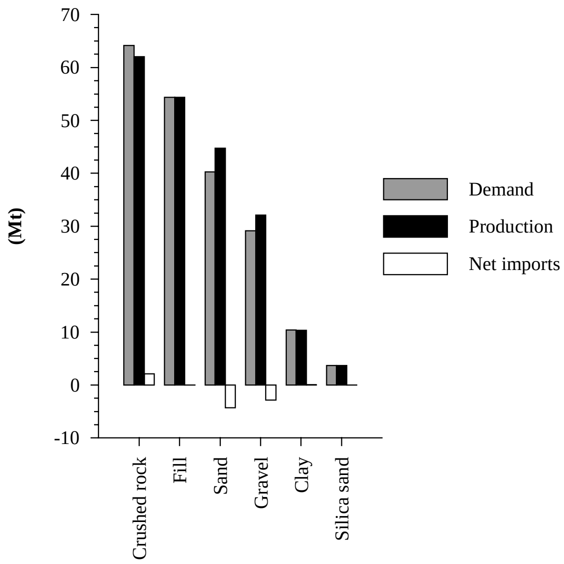

Fig. 8. The provision of aggregates, clay and silica sand in England and Wales in 2000 (data from Harrison et al., 2003). Limestone data are only available for the whole of Great Britain.

The production of secondary materials, such as construction, demolition and asphalt waste, slag, ashes and colliery spoil, was about 139 Mt in England and Wales, and 9 Mt in Scotland. 47 Mt (33%) of this amount were re-used in England and 4 Mt (41%) in Scotland.

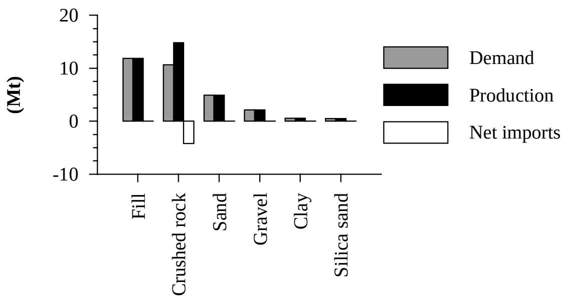

Fig. 9. The provision of aggregates, clay and silica sand in Scotland in 2000 (data from Harrison et al., 2003). Limestone data are only available for the whole of Great Britain.

The use of renewable materials for building and construction is limited to timber. The number of houses built yearly that are timber-built or timber-framed is estimated at about 10% for England/Wales and about 50% for Scotland.

The British national government provides planning guidance for mineral extraction (Anonymous, 1996b). State authorities develop views on regional planning guidance, development plans and planning applications. The English and Welsh policies aim at an adequate supply of building materials and a maximization of the use of secondary materials (Anonymous, 2000b, 2000c, 2000d, 2000e, 2001c, 2001d). Within the framework provided by these views, the economic planning regions develop mineral planning guidance policies. These are implemented by the authorities responsible for minerals and waste planning, and the issuing of extraction permits: the county councils, unitary authorities and national parks. Sea bed extraction permits are issued by the Crown Estate, which manages Crown-owned land and marine domains (almost the entire British sector of the North Sea).

The Scottish Executive aims to combine economic growth with care for the environment (Anonymous, 2001e). Regarding the aggregates provision, this translates to an adequate supply for building and construction, taking into account landscape, amenity, nature, agriculture, cultural heritage and water interests. The national planning policy is implemented by local planning authorities, which deal with mineral planning in the broader scope of local development plans. The Scottish Executive supports aggregates production for exports from coastal superquarries, but wants to limit the number of such exploitations for environmental reasons. Scottish planning guidance for secondary materials is limited to the recommendation that planning policies should provide for reworking of mineral waste deposits, and the recycling of construction and demolition waste.

In 2002, an aggregate levy of £1.60 (~€2.35) has been introduced in the whole of the UK, in order to address the environmental costs associated with quarrying (noise, dust, visual intrusion, loss of amenity, and damage to biodiversity). Neither the English/Welsh, nor the Scottish policy aims at the substitution of non-renewable raw materials by renewables.

Relevant EU legislation and policy

Some aspects of the extraction, processing and application of the materials considered are governed by EU legislation and policies on the environment and sustainable development adopted by the studied countries. The extraction of minerals and related planning and/or permitting policies are subjected to EU-defined environmental impact assessments (Anonymous, 1985, 2001f). The utilization of secondary materials is promoted as a part of EU strategies on waste management (Anonymous, 1997b) and sustainable use of natural resources (Anonymous, 2002d). Policy lines specifically addressing sustainable development of the EU non-energy extractive industry have been proposed in 2000 (Anonymous, 2000f; see also Anonymous, 2003).

Trans-boundary trade

General

In 2000, about 65 Mt of aggregates were traded between the countries in the study area, which is about 13% of the total production of 508 Mt (disregarding fill material). The trade volumes for the other materials are 3 – 6 Mt (4%) out of 79 Mt of limestone for industrial use, 1 Mt (2%) out of 46 Mt of clay and 2 – 3 Mt (9%) out of 27 Mt of silica sand.

The consistency of the aggregates data is sufficient for mapping imports and exports (Fig. 10 – 13). Ranges shown are introduced by differences in the data sets of the exporting and importing countries, either quantitatively, or arising from differences in definitions (e.g. sand vs. gravel). The origins of imports of non-aggregate materials and the destinations of exports are poorly known.

Sand and gravel

The most significant trade in sand occurs between Germany and the Netherlands, and between the Netherlands and Belgium (Fig. 10). The sand imported by the Netherlands from Germany is generally coarser than the sand exported from the Netherlands to Belgium (Van der Meulen *et al*., in press). The most significant trade in gravel occurs between the Netherlands and Germany, and between the Netherlands and Belgium (Fig. 11).

Exports from the UK shown in Fig. 10 and 11 are the sand and gravel fractions in marine-dredged sand-gravel mixtures, which are classified in the importing countries.

Crushed rock

Crushed rock is transported over larger distances than sand and gravel. Fig. 12 clearly identifies three major exporting states: Scotland, Norway and Belgium. The larger part of their export volumes are imported by the Netherlands and Germany.

Net trade in aggregates

Fig. 13 shows the net trade in aggregates in the study area. Scotland, Norway and Germany are the main exporting states; the Netherlands and Belgium are net importing states.

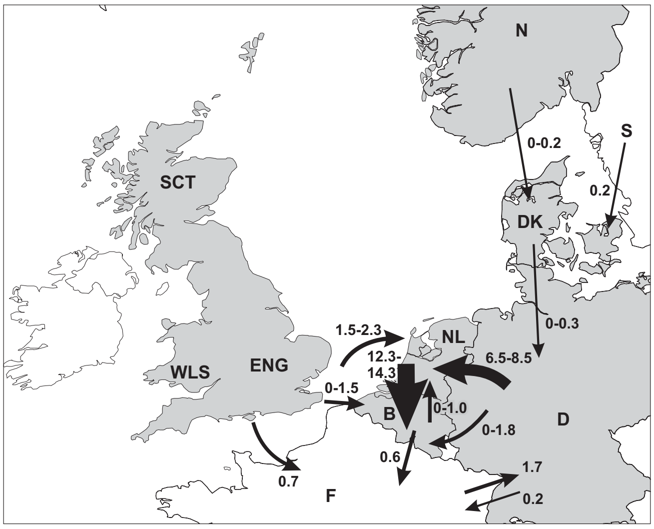

Fig. 10. The trade in sand (filling sand excluded) in the study area in 2000; figures in Mt.

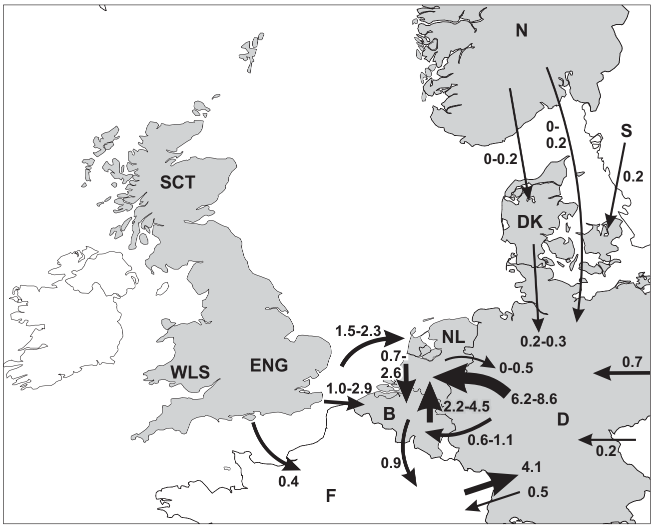

Fig. 11. The trade in gravel in the study area in 2000; figures in Mt.

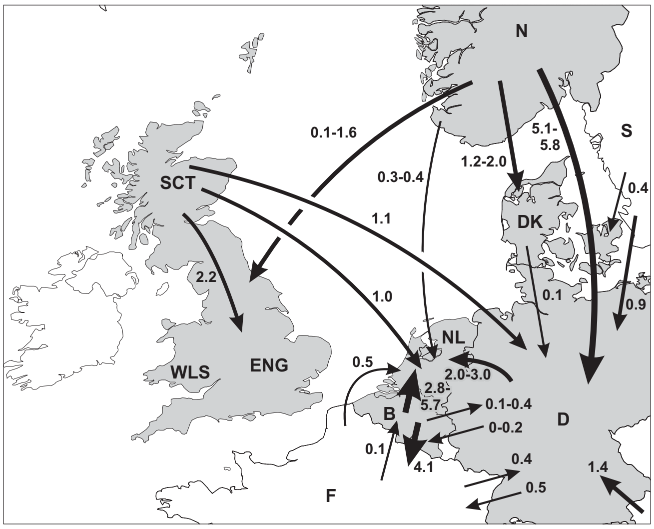

Fig. 12. The trade in crushed rock in the study area in 2000; figures in Mt.

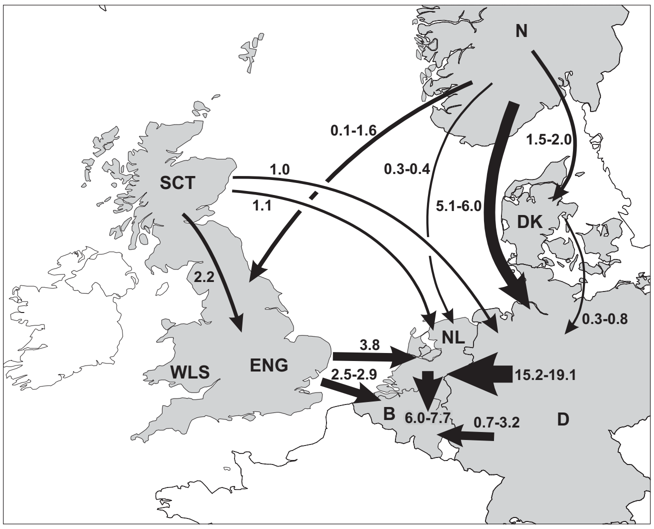

Fig. 13. The net trade in aggregates in the study area in 2000. The arrows indicate the direction of net supply, the absolute difference between exports and imports (given in Mt).

Sustainable extraction

General

All the studied countries aim, to a varying extent, to minimize the environmental impact of mineral extraction. Strategies to achieve this include the stimulation of an economical materials use and recycling. Some countries have added substitution of primary materials by renewables.

Economical use of raw materials

The average consumption of aggregates in the study area was about 6 t/capita in 2000. Differences between states seem to be largely explained by their macro-economical situation: Fig. 14 shows a fairly good correlation between the gross domestic product and materials use per capita. There is no clear-cut explanation for the observed consumption pattern arising from differences in policy.

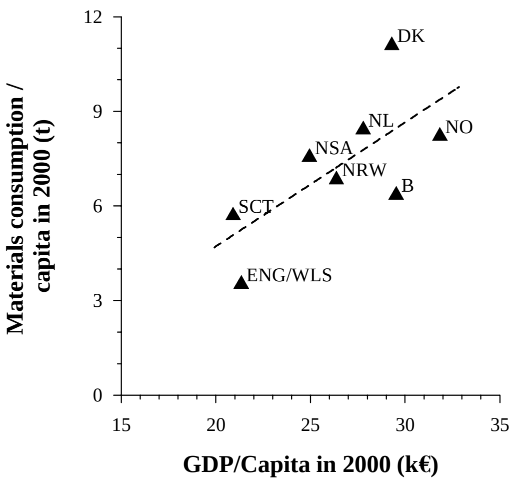

Fig. 14. The relationship between gross domestic product (GDP) per capita and aggregates consumption per capita.

In some individual cases, consumption levels can be attributed to a specific environmental factor. The western and northern parts of the Netherlands, for instance, have a largely muddy or peaty subsurface. Building in these areas tends to result in compaction of the underlying soil, and building requires above-average amounts of fill material. When fill is disregarded, the Netherlands ranks among the countries with the lowest materials use (Fig. 15).
High demands for aggregates brought about by unique geological or geographical factors still have to be accommodated financially. Accordingly, the existence of such factors does not interfere with the general dependency on prosperity (Fig. 14).

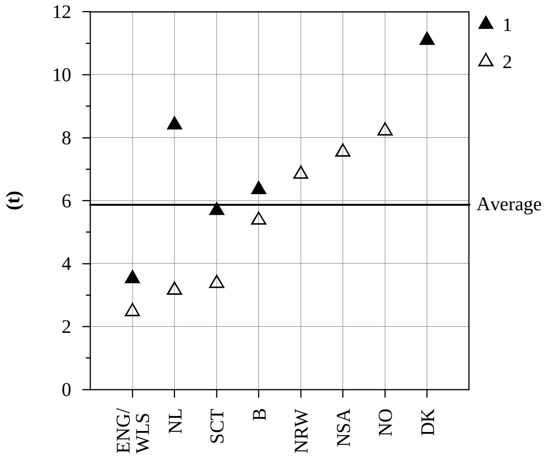

Fig. 15. Aggregates consumption per capita including (1) and excluding fill material (2). Fill material consumption is not monitored by Germany and Norway, and is not included separately in the Danish data.

Secondary materials

Various earthy and stony secondary materials are used as alternatives for the commodities considered in this study. Coarse and medium grained secondary aggregates, such as stony construction and demolition waste, slag and bottom ashes are mainly used as foundation or fill materials, substituting sand, gravel and crushed rock. Fine grained industrial and energy production by-products are used in the building materials industry, e.g. as a pozzolanic or hydraulic component in cement, substituting primary materials such as limestone and clay (Hendriks & Pietersen, 2000).
Fig. 16 displays the utilization of some secondary materials in two ways: the total consumption in 2000 (upper panel) and recycling percentages (lower panel). As recycling and waste management are often discussed in the context of scarce space, Fig. 17 shows the relationship between the recycling percentages, the share of secondary materials in the total provision, and population density.
The highest recycling percentages occur in the Netherlands, Denmark and Belgium. The Netherlands and England/Wales have relatively high shares of secondary materials in the total provision of minerals considered in this study. For Norway both values are low. Denmark has a high recycling percentage; however, given the high overall aggregates consumption (Fig. 14, 15), the share of secondary materials in the total provision is low.

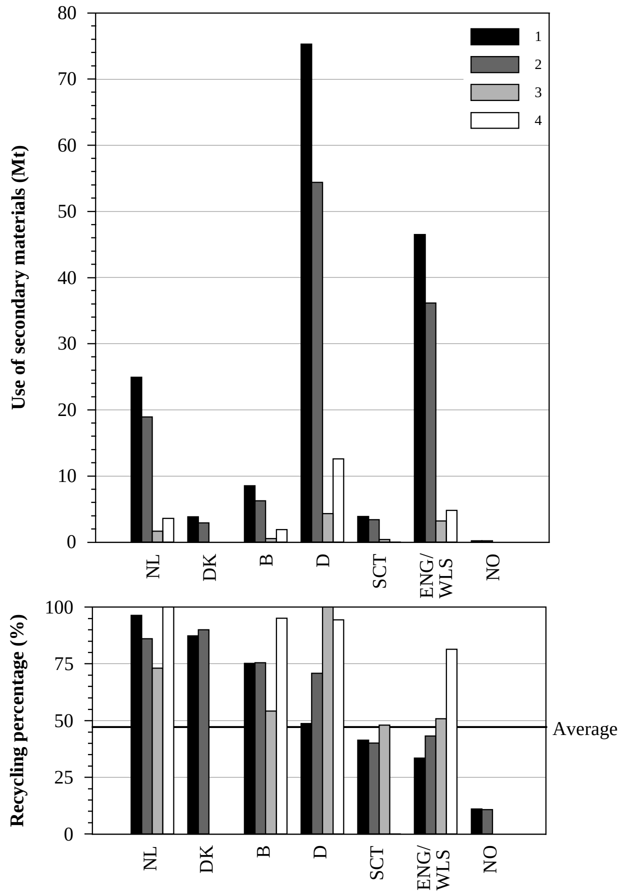

Fig. 16. The use of secondary materials in the study area (see text for explanation): 1) all secondary materials, 2) construction and demolition waste and asphalt waste, 3) ashes (coal, and MSWI fly and bottom ashes), 4) slag (blast furnace slag, steel slag, phosphorous slag). The reader is referred to the regional reports for data on specific secondary materials. Data for individual German states are not available.

Altogether, there is some correlation between the utilization of secondary materials and population density (Fig. 17). This suggests that recycling and waste management is indeed more of an issue if space is considered an asset. Denmark, having a relatively high recycling percentage at a low population density, and England/Wales vice versa, are the clearest exceptions to this.

Renewable materials

The use of renewable building materials is supported in most of the studied countries. However, in contrast to secondary materials, none of the studied countries have set quantitative targets. Fig. 18 shows the share of timber-built and timber-framed houses, which is the only quantitative result on renewable materials use obtained in this study.
Although using renewable and recycled materials are equally consistent with the concept of sustainability, the share of timber-framed houses and the recycling percentage of secondary materials are not at all correlated. On the contrary, Norway and Scotland, having below average recycling percentages, make the highest use of timber in building. The Netherlands, Belgium and Denmark, having the highest recycling percentages, have the lowest shares of timber-use.

This is consistent with the observation that the use of timber is driven by tradition and local availability rather than policy.
The Dutch building materials provision policy treats shell valves as a renewable resource. The annual permitted volumes in the primary extraction areas are limited to the estimated average yearly growth increments of the exploitable shell stocks (Beukema & Cadée, 1999).

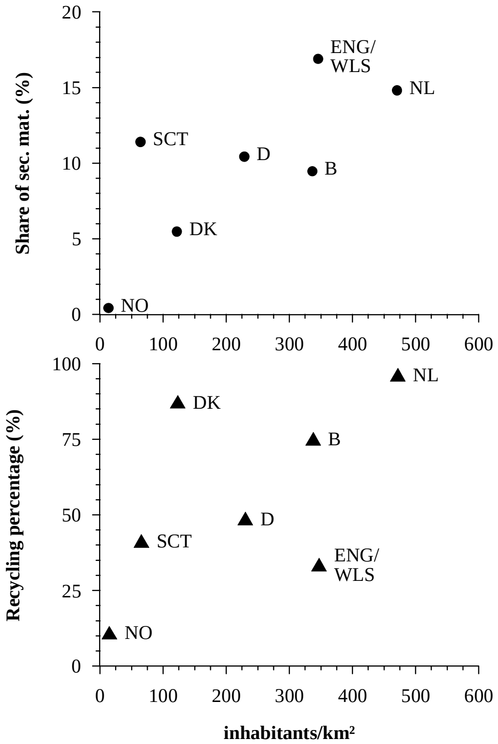

Fig. 17. The use of secondary materials in the study area vs. population density. The shares of secondary materials in the total German provision is an overestimate, because fill material is disregarded (for lack of data).

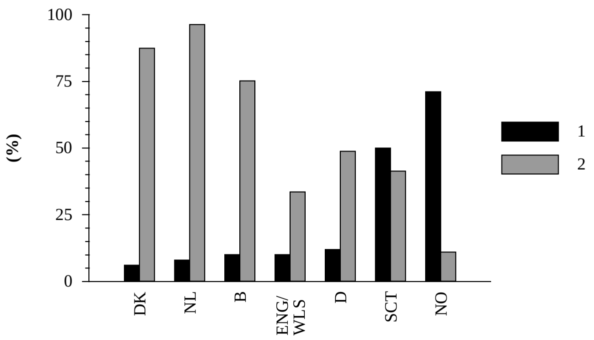

Fig. 18. The share of newly built timber-framed and timber-built houses in the study area (1) and recycling percentages for secondary materials (2, as in Fig. 16 and 17, lower panels).

Sea bed extraction

In the past two decades, the Dutch government has actively stimulated a shift from land-won to sea-won filling sand, in order to decrease the impacts of land extraction. The main reason for this has been the societal resistance against on-land extraction. As yet, it is not clear whether or not the shift is desirable from an ecological point of view. In the other countries, sea bed extraction is mainly undertaken because of the availability of aggregate resources. Fig. 19 shows that the highest share of sea-won aggregates in the total provision occurs in the Netherlands.

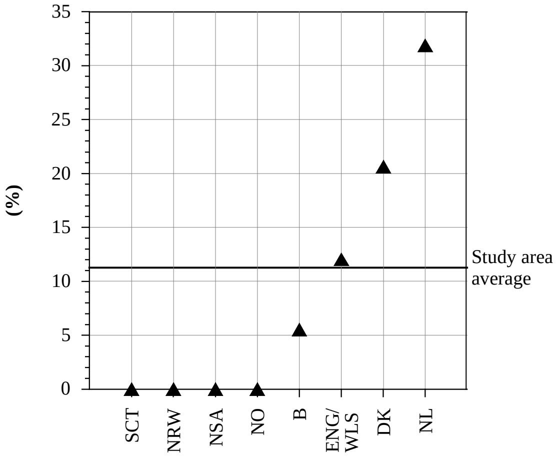

Fig. 19. The share area of sea-won aggregates in the total aggregates provision in 2000.

The level of self-supply

Fig. 20 (middle panel) shows the production/demand ratio for aggregates, a proxy for the extent to which the studied countries are self-supporting. Fill material, which is hardly traded internationally, has not been taken into consideration. The figure is consistent with Fig. 13: the ratios of the net exporting states Norway, North Rhine-Westphalia, Scotland and England/Wales are > 1. Lower-Saxony, Denmark and the study area as a whole are self-supporting. Belgium and the Netherlands are net importing countries.
The production/demand ratio is partly related to the available geological stocks. Belgium has limited sand reserves, the Netherlands has limited reserves of coarse aggregates; in both cases, certain levels of import are inevitable. Another factor affecting the ratio is policy governing the exploitation of resources. The middle panel of Fig. 20 shows the production/demand ratio for the most amply available aggregate or aggregate category. Belgium, though overall dependent on imports, is a net exporter of crushed rock. This illustrates the fact that the Belgian extraction policy does not contribute (significantly) to the low overall level of self-supply. The Netherlands, on the other hand, is a net importer of concreting and masonry sand, of which large resources are available in the southeastern and eastern parts of the country. In fact, the Netherlands is the only country in the study area which maintains an underproduction of an amply available aggregate.
The production/demand ratio correlates quite well with the average amount of surface extraction production per km² of land surface (upper panel of Fig. 20). This suggests that the extent to which states are prepared to allow extraction is at least partly related to the average land use of mineral extraction. High aggregate production levels per inhabitant and production for exports occur at low amounts of surface extraction per km², i.e. in Norway and Great Britain. North Rhine-Westphalia, where the production of aggregates exceeds the demand even at very high production levels per km², is a clear exception. A similar relationship exists for

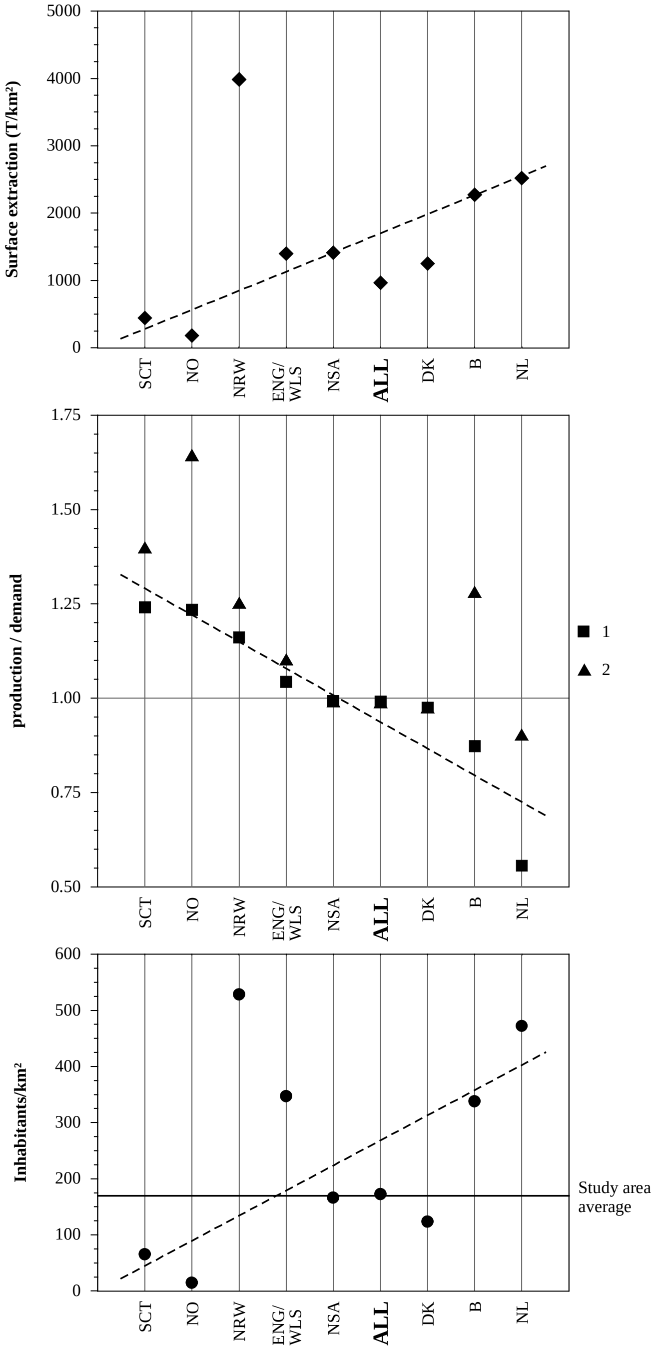

Fig. 20. Middle panel: the level of self-supply per country: 1) for aggregates in general (fill material excluded) and 2) for the aggregates (category) from the largest geological stocks (i.e. crushed rock for Norway, Scotland and Belgium; sand and gravel for North Rhine – Westphalia, Lower Saxony and England/Wales, (coarse) sand for the Netherlands). The upper and lower panels show the correlations of the level of self-supply with the average extraction per km² (all materials) and the population density, respectively (dashed lines to guide the eye). See text for further explanation.

the production/demand level and the population density. Generally, high production levels are associated with a low population density. Again, North Rhine-Westphalia, having the highest population density as well as the highest production level, is the most notable exception.

Scotland and the Walloon region have specifically related extraction for exports to economical development. However, Fig. 21 shows that the inclination to produce for exports is not limited to countries with relatively low GDPs.

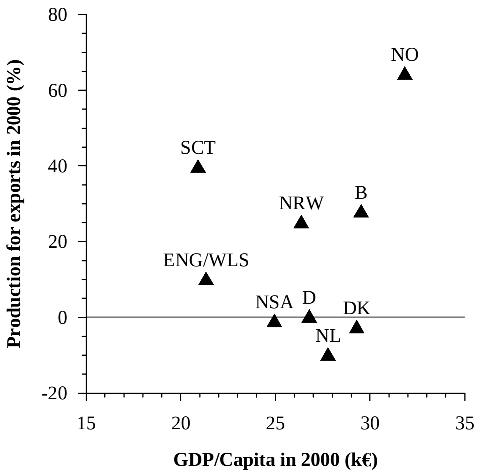

Fig. 21. The level of self-supply per country for the most amply available aggregate or aggregate category (see caption of Fig. 20), plotted vs. the gross domestic product per capita.

International comparisons

General

Each of the studied countries has a policy for the exploitation of the surface mineral resources considered in this study: aggregates, limestone, clay and silica sand. Shared topics mainly relate to sustainability (e.g. minimization of extraction, economical materials use, recycling, environmental impact assessments), most probably because this is a well-established EU policy theme. However, sustainability indicators, such as the aggregates consumption per capita, the recycling percentage of secondary materials and the share of secondary materials in the total provision, reveal large differences. Policy results in sustainability objectives and trends; the absolute level of indicators is usually related to other factors, such as the building tradition, population density, economical considerations, etc. In fact, mineral planning policies primarily provide guidelines for permission authorities, and hence mainly affect materials supplies. There are no effective policy instruments regulating the use of primary materials once extracted.

The stimulation of secondary materials use has been successful in most of the study area. Part of the success can probably be attributed to the fact that recycling is a shared objective of mineral planning and waste management policies. Especially taxation and banning of landfilling with recyclable materials has proven to be effective.

The study area as a whole is virtually self-supporting for the materials considered. It hosts sufficient resources, and the North Sea and the rivers Rhine, Meuse, Scheldt and Elbe provide bulk transport infrastructure.

Regional

There are pronounced differences in the extent to which countries are willing or able to extract the studied materials. Scotland, the Walloon Region and Norway favor production for exports of aggregates. A significant share of the aggregates extracted in North Rhine-Westphalia and from the British sector of the North Sea is exported, which is possible under the current permission policies, but not explicitly favored. The importing countries either face resistance against extraction, such as the Netherlands, or have limited reserves, such as the Netherlands and Belgium. Denmark and Lower Saxony are more or less self-supporting, in accordance with their possibilities and policies.

The Netherlands and North Rhine-Westphalia

The intended effects of the Dutch restrictive permission policy are an ever more economical materials use, the stimulation of alternative (secondary or renewable) materials, and a shift towards sea-bed extraction. There have been measurable positive results: recycling percentages, and the shares of secondary and sea-won materials in the total provision rank among the highest in the study area, the aggregates use (when disregarding fill material) among the lowest. However, the policy has also brought about substantial imports. In policy, this is considered a side-effect, of which the consequences are not measured according to the same standards as the domestic effects.

The German states have formulated a goal of minimizing transportation of building materials. North Rhine-Westphalia is currently accommodating the larger part of the Dutch underproduction of sand. This is not entirely consistent with the transportation objective, but it can apparently not be prevented under the current non-restrictive permission policy.

The trade relationship and production differences between North Rhine-Westphalia and the Netherlands have recently been criticized in Germany, e.g. by the joint North Rhine-Westphalian environmental organizations (Gerhard, 2002). The fact that some aspects of the relationship seem unintentional may call for some policy harmonization.

Future trends, recommendations

Societal resistance against mineral extraction has been an issue in three consecutive European conferences on Mineral Planning (Van der Moolen *et al.*, 1998; Fuchs *et al.*, 1999; Anonymous, 2002c). Research and policies of most of the studied countries are in some way directed towards sustainable extraction. In this context, production restrictions are often considered a solution to resistance on local up to regional scales.

If this would be pursued by North Rhine-Westphalia, the Netherlands and Belgium may face scarcity of aggregates. To some unknown extent, the associated price effects will allow for higher levels of recycling, or the exploitation of geologically poorer resources. However, there are limitations to what can be achieved on a national level under conditions of scarcity. Therefore, the Dutch and Belgian building and construction sectors will probably be forced to consider aggregates imports from more remote countries. Also, Dutch permission authorities will probably be asked to reconsider restrictive policies.

Altogether, regionalization of the aggregates production within the study area, aimed at sustainability, could have the adverse effect of increasing transports of aggregates towards or within the study area. The Commission of the European Communities puts sustainable development of the quarrying industry in an international perspective (Anonymous 2000f). It recommends the best use of locally available resources as a basic principle, and full impact assessments, comparing local and more remote sites, as a standard in permitting procedures.

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