Give Peas a Chance: Transformations in Food Consumption and Production Systems

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Abstract

Food production chains can be organised in a variety of ways. Conventional 'industrial' agricultural practices are based on advanced breeding techniques and major inputs of chemical fertilisers and pesticides. Food produced in this way is transport-intensive, requires high-energy processing, relies on modern retailing systems and demands high-tech kitchens. Many argue that the industrialised systems should be dismantled and replaced with alternative methods of agriculture, food processing and distribution that emphasise social and environmental sustainability. This paper looks at the environmental and social sustainability of different strategies for food systems by analysing the whole chain of production, processing, distribution and consumption activities of the production of frozen peas, a vegetable that is 'symbolic' of modern food systems and the UK diet. It looks at such issues as: Which technologies are seen as critical for determining sustainability in the pea production chains, and which actors are promoting technological change? What are the implications for technological innovation of different pea production and consumption strategies? To what extent do the different strategies ensure variety from which future technological innovations will emerge?

INTRODUCTION

Technological innovation and the changes in supporting economic and social structures that come with it (collectively known as "innovation") must be central to the achievement of sustainable production and consumption in all areas of human activity. If current systems of production and consumption are unsustainable in terms of their resource usage, ecological impact and long-term environmental effects, then new systems of provision are needed, entailing new processes, new products, new services and new management practices; if these do not exist, they will have to be invented and launched into social and economic use. Conversely, new forms of social relationships that are innovated with environmental improvement as their goal will inevitably use products and processes in new ways. There is thus a strong relationship between innovation in socio-economic arrangements and innovation in the material products and processes in which they are entwined – *sociotechnical systems of provision* as they might be called. Consequently, understanding the processes that are likely to underpin these developments is crucial for policy intervention to achieve desirable forms of sustainability.

In this paper, we explore socio-technical systems for the provision of *food.* As an example, we explore the dynamics of the system for the production and consumption and production of the *frozen pea* in the UK. We look at various alternatives to the current system – represented through 'advocacy strategies' by proponents of the alternatives - that are argued as being more 'sustainable'. We analyse the frozen pea system to identify the sources of technological control and possible innovation solutions in dealing with the system's 'unsustainabilities'. We might expect that similar analyses could be done on the systems of provision of other types of food (and indeed these are the subject of a research project from which this paper is derived).

FOOD SYSTEMS AND 'TRANSFORMATIONS'

Introduction

As one of us has argued elsewhere (Green, Harvey and McMeekin (forthcoming)), the notion of 'sustainability' in its broadest meaning, as opposed only to the reduction in the environmental impact of individual products or agricultural or industrial processes, requires thinking in 'systemic' terms.[1] Transforming human activities with respect to food implies a focus on the whole system of agricultural, industrial, retailing and household 'sectors' and their interrelationships, with their strongly connecting regional, national and international dimensions. In addition, systemic thinking is concerned with more than the production of food, in agriculture and food processing factories; it also includes distribution and the preparation of final meals whether this be in individual households or in more communal arrangements whether commercial or non-commercial. We can thus define Food Consumption and Production Systems (FCPSs) to include the whole 'chain' of human-organized activities concerned with the production, processing, transport, selling, cooking and eating of food and the disposal of the wastes of such activities.[2] Thinking 'systemically' allows a focus on an important, if neglected, aspect of sustainability, namely the intimately connected relationships of production with consumption.

System strategies

[1] See Lifset and Graedel (2002) for a justification for this.

[2] For details of the elements of the Food System, see Tansey and Worsley, 1995; Millstone and Lang, 2003, present current information on global food production, trade and consumption in atlas form.

We would claim from the literature on food and sustainability that it is possible to identify different system 'strategies' for the ‘organisation’ of Food Systems. Strategies for new systems are usually described in opposition to the supposedly dominant institutional forms of food production, distribution and consumption to be found in the OECD countries and said to be the form that is diffusing most rapidly into developing countries. This *'industrialised/ modern'* FCPS is based on 'Fordist' principles of seeking high labour productivity and economies of scale in all elements of the system, especially in agriculture and food processing. Fordist principles have been increasingly extended to distribution, with the domination of supermarkets in retailing and mass catering in eating-out. Household consumption is based on a wide variety of mass produced commodities with a historically high consumption of animal products. Agriculture and food processing is the subject of continuous innovation, based on scientific understandings. There is a constant search for innovation in products and agricultural/factory processes. This ‘industrialised/modern’ form FCPS is much caricatured by critics, not just for the quality of the food it provides (with rising concerns about food safety and hygiene) but also for its insensitivity to environmental and animal welfare concerns.

What alternatives to ‘industrialised/modern’ systems are there? For developed countries, there are only two contenders. The first can be labelled the *‘organic’ strategy*. [3] Advocates of organic systems focus on food production that engages with natural systems and cycles in agriculture and processing. They approve of the proposed dismantling of 'industrialised' systems that are prevalent in rich countries and their replacement with methods of agriculture, food processing and distribution that emphasise social sustainability. Much cultural significance is given to 'natural' products and production methods as a means of ensuring health - of humans, of farm animals and of the eco-system in general. Agricultural pollution (especially damage to soils and water courses) can be minimised by the avoidance of 'chemical' inputs into agriculture (synthetic fertilisers and pesticides) with the use of closed nutrient cycles (with much waste recycling). The use of GM seeds would be completely ruled out. Some advocates of this strategy go further than a concern with agricultural methods; they see it as part of a socially and ecologically responsible approach to the production and distribution of food, with a strong bias to bioregionalism and against large-scale world food trading, though some organic food grown in large farms for international export can be countenanced.[4]

The second strategy we have called *'new industrial'*: 'new' because it is advocated as a restructuring of the 'industrialised/modern' strategy to take account of a number of scientific and technological developments of the last 20 years.[5] It takes seriously criticisms of the environmentally-destructive nature of post-1945 methods of high-productivity agriculture. This leads to the introduction of new methods of crop management, often using Information Technology, and diversification of agriculture into new materials. The strategy could readily incorporate the technical and certification features of the 'organic' strategy, though not the other, more social and bioregionalist aspects of the organic movement. Secondly, it allows the use of genomic knowledge to develop new seed varieties both through genetic engineering and traditional breeding methods enhanced by a better understanding of a crop’s molecular biology. This is seen as a huge jump from mere 'Monsanto-type' genetic modification, which used genome knowledge linked only to changes in the use of agrichemicals. This knowledge

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[3] The arguments here are based on Brown *et al.,* 2000; Soil Association, 2001; Wright and McCrae, 2000

[4] At the moment, organic food is internationally-traded and sold through supermarkets, whose sales of such food is rising rapidly in the richer countries. This is unacceptable to many supporters of organic agriculture - notably those in the 'organic movement' - whose broader agenda is bioregionalist.

[5] This account is based on Ford, 2000; Conway, 1997; Manning, 2000; Heasman and Melletin, 2001

also presents the opportunity to improve crop protection technologies, through a better understanding of crop pathogenicity. There are a number of benefits to be gained from better understanding of the full genetic makeup of crop plants and food animals, as part of extending the benefits of the Green Revolution beyond the basic crops of maize, soya and rice. Thirdly, it takes on board the notion of foods as a way of delivering health care, through the development of functional foods and 'nutraceuticals'. The strategy is still based on high outputs in agriculture and processing within internationally-organised production and trade. It continues the strong 20th century emphasis of the industrial/modern system on high output and low labour agriculture and innovation in agriculture and food processing based upon science. Farms would still be large with high productivity (and low labour inputs) but with new developments in soil and pest management that allow more eco-sensitive approaches to biodiversity. Greater attention would be paid to hygiene and quality, especially in relation to animal products with the development of new non-soil methods of food production (e.g. fungal protein). The strategy thus continues the focus on producing large quantities of food for rapidly expanding urban populations. It seeks to respond to the undoubted environmental degradation that 20th century agriculture has caused by the application of new technologies, but by the application of further modern technologies – especially in biotechnology – that are considered risky by many environmentalists.

In the next part of the paper, we explore a system of provision of one particular food, seeking to identify the potential for the alternative strategies that are advocated as preferable to Fordist systems. The production of frozen peas can be seen as *the* example of a Fordist production and consumption system. Sustainable alternatives to it need to be considered to give peas a chance

GIVE PEAS A CHANCE

Introduction

According to Robert White, ex-President of the US National Academy of Engineering, Industrial Ecology is "the study of the flows of material and energy in industrial and consumer activities, of the effects of these flows on the environment and of the *influences* of economic, political, regulatory and social factors on the flow, use and transformation of resources."(1994, emphasis added) The direction of flow between the 'physical'/'material' world and the 'social/economic/political' world is, in this definition, one in which the social 'influences' the physical. But – as work in innovation studies continues to show – it is possible to see the physical-social relation in a different way, with the process of innovation being 'embedded' in structures of social relations (including those that inform consumption patterns and practices), inter-industrial relations, technological relations, and capital/investment relations. A key idea is how we can re-think the link between the *flow of materials*, a flow which Industrial Ecology is especially skilled at analyzing, with the *social, economic, and organizational structures* which cause physical flows to be and become 'clumped' (concentrated/dispersed) in particular ways. We can also proceed to identify empirically the location(s) of *actual innovative* change within those structures. We can further identify *potential* sites for innovation, together with, importantly, constraints to change and reasons for resisting change.

To elaborate, we can conceive four structural domains which together provide organisational logic to the system. They are: the structuring of materials flow; the structuring and organisation of economic activity together with the pecuniary redistributions which arise from the processing of those materials; the social structures and structuring of relations (including power relations) which demarcate classes of agent and, finally, the production of structures and meanings of knowledge including how that knowledge (and its associated symbolic significance, the ways meanings are produced and interpreted) is generated and applied.

Peas: Industrial Ecology and Innovation

Figure 1 presents a "system map" for the *frozen pea* in the UK. The frozen pea is especially important, symbolically if not quantitatively or nutritionally, for the UK diet. It is *the* green vegetable, the first one to be available in a frozen form in the 1950s and the first to have its consumption, in a 'fresh' form, detached from its seasonality. It symbolizes other things as well – as something that might be considered 'unsustainable', both in growing it and in freezing and distributing it.[6] As such it has become the subject of examination by its major processor in UK – Unilever/BirdsEye - through its work, in partnership with the Forum for the Future on the Sustainable Pea.[7] The focus of the FftF/Unilever initiative is in making the agricultural methods of pea production more sustainable by, for example, reducing the quantities of chemical inputs suggesting that there are or should be other, and more 'organic', methods of agriculture. However, there are other aspects of the frozen pea's ecological impact which also need to be considered. We need to consider *all* the resource inputs and ecological impacts before assuming that *pea-growing* - the agricultural part of the system - is the (only) problem. And we need to identify the sources of technological control and possible innovative solutions in dealing with any of these unsustainabilities; in particular we need to take account of the apparently only fixed point in the whole pea system map: the continued place of frozen peas, conveniently purchased year-round at a low price, in UK meals.

A food system is thought of here as a sequence of activities, starting with the production of plant seed, that link together to bring food to consumers' mouths. If we want to analyse the implications of the existence of a certain food system for society, the environment and technology we must start with three questions:

- What characteristics of society, technology and the environment enable the system to exist as it does?
- What are the consequences of its existence?
- What tensions within the system exist between pressures for change and pressures for stasis, and how are these resolved as outcomes/processes of adjustment and co-evolution?

The overall system map included as Figure 1 shows a string of basic activities.[8] However, we have not just drawn a flow diagram of the elements of the pea agricultural, processing and distribution system (something that we would expect from a straightforward IE-type study). We have added those elements that indicate how the system is controlled by a number of "core" organisations, with inputs from and outputs to its socio-economic environment, the "technosphere" and the natural environment. By technosphere we mean the set of human activities which transforms naturally-occurring resources into the forms used in

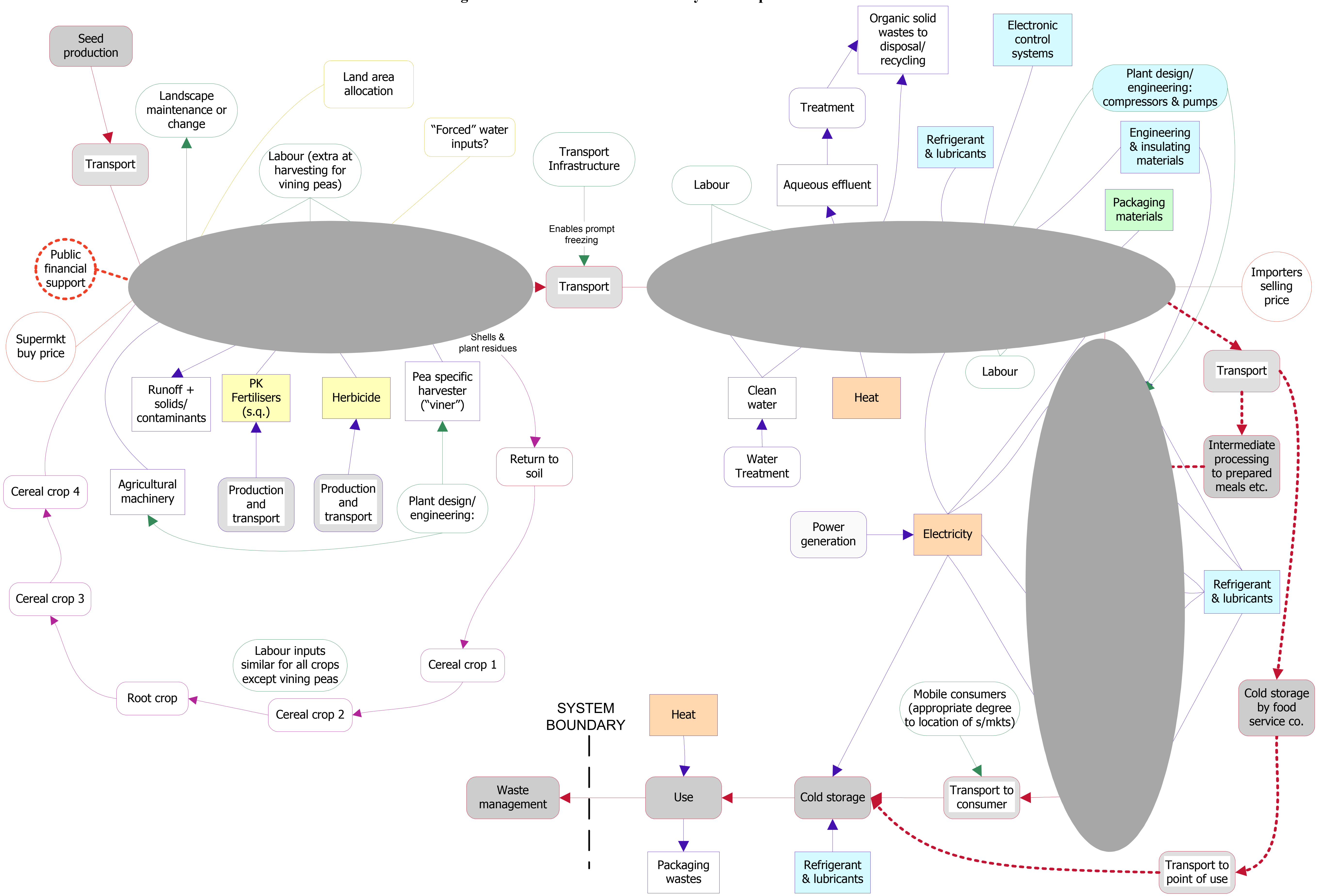
[6] Its symbolism might be illustrated by the dust-jacket of the recent book by Felipe Fernandez-Armesto, 2001. Fernando-Armesto is an Argentinean academic, who works in the US and Europe, and is especially critical of modern food consumption practices. His publisher has chosen to depict an opened pea-pod on the front of the book, despite the fact that the pea is only briefly mentioned in the book as part of Fernando-Armesto's denunciation of frozen foods in general.

[7] Forum for the Future/Unilever, no date

[8] The picture of the frozen pea system presented here has been developed by reference to a variety of published material supplemented by interviews with growers' representatives, processors and a small number of other food industry sources. For discussion of Life Cycle Assessment, see "The Eco-indicator 99: A damage oriented method for Life Cycle Impact Assessment. Methodology Report" PRé Consultants B.V. 2000.

the system under study, and turns wastes from that system back into substances that are released into nature. The catalogue of inputs and outputs is not exhaustive: there would not be space in a graphic representation of this sort for such a listing. We have tried to focus on "critical" inputs and outputs, namely those without which the system could not exist in this form.

Figure 1 Frozen Peas in the UK – A System Map



The Pea Consumption and Production System: the Materials Flow

The basic materials flow within the full system diagram is extracted in Figure 2. The system is centred on growers in the UK. The UK is both the largest grower and consumer of immature, or vining, peas (as distinct from dried peas) in Europe. Some 35-40K hectares are dedicated to their cultivation in this country, with this area tending to fall with time. Because of this selected focus, the geographical locations of some of the activities in this sequence are defined or constrained. Such activities are shown in Figure 2 as boxes with no shading. Many activities in the sequence entail transport or motor-powered vehicles: these are denoted by hatched boxes. Boxes with grey shading then denote activities which are static but are not geographically-constrained by virtue of our focus on UK grown peas.

On the farm: There are a number of seed suppliers from whom growers can source seed for peas. By definition the chain of activities from planting to harvesting is geographically fixed, but we draw attention to the fact that planting and harvesting are dependent on the use of motorised equipment. A key aspect of the freezing of immature peas is the time that elapses between picking and freezing. This is portrayed as being a critical factor in determining the taste of the finished product. Indeed, the idea that no pea is packed more than 150 minutes after it has been picked features in the marketing of some brands. (As an old advertising jingle put it: BirdsEye peas are "Fresh as the moment when the pod went pop".) While other processors have no specific commitment, all apparently aim for similar levels of performance. This has two implications for the system:

- Harvesting involves many small vehicles to transfer peas quickly from field to bulk road haulage container; and
- The location of processing plants is geographically constrained to being reasonably close to the farms. We have not done sufficient research to establish a specific radius: however, since the 150 minutes must include time to fill a 40-foot trailer, and time to offload, wash, blanch and freeze the peas as well as actual travelling time, it seems unlikely that this would be greater than 100km.

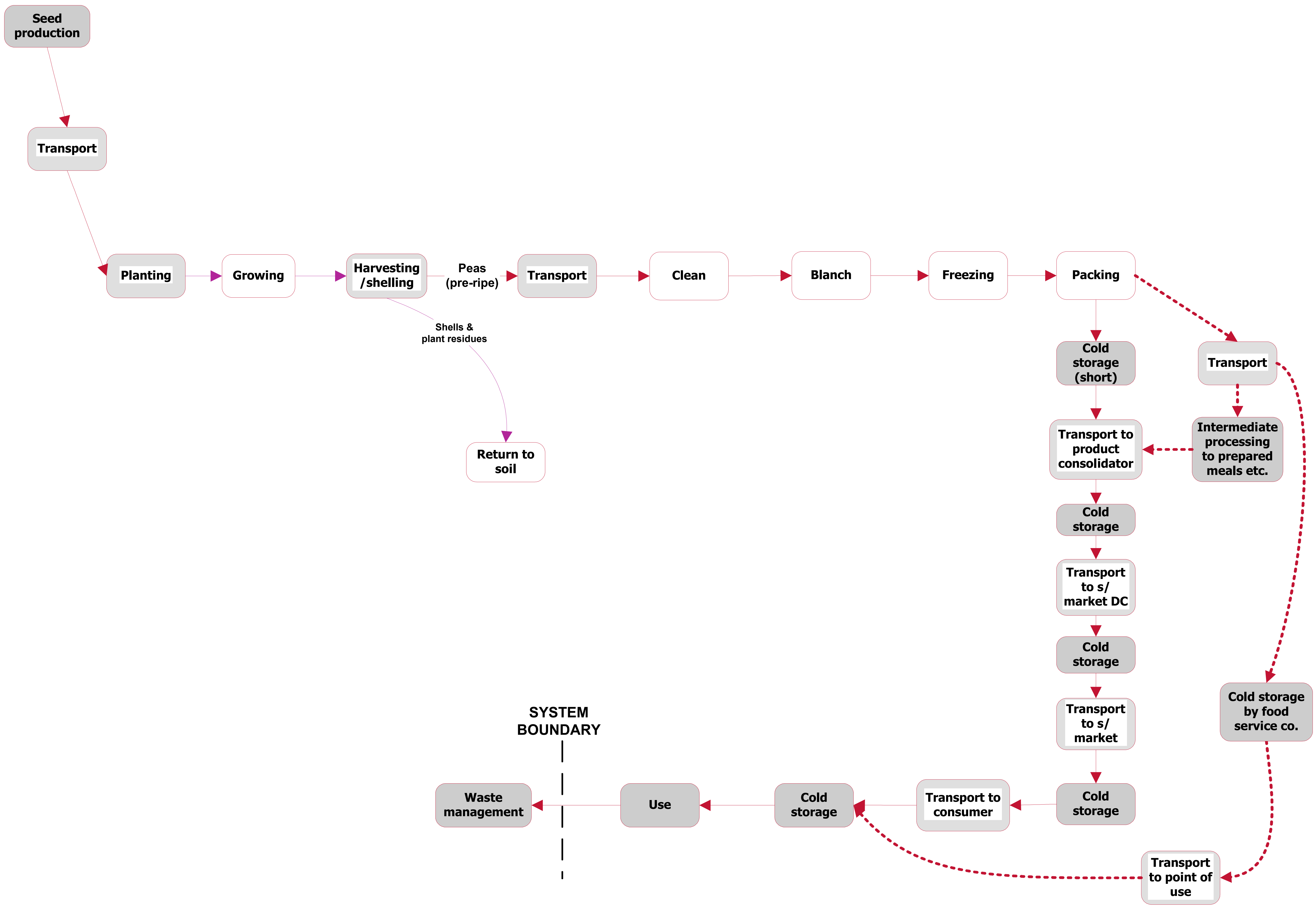
The harvesting equipment (known as a *viner*) also separates the peas from their pods and the remainder of the plant. These residues are later returned to the soil.

Into the freezer: On arrival at the processing plant, peas are cleaned and checked, then blanched (partly cooked by immersion in very hot water, before being frozen and packed. Fluidised bed freezers are used to allow efficient heat transfer from cold air to pea.

Through the distribution chain: The activities that follow processing are common to most food ingredients. A proportion will be shipped on to other food businesses that produce prepared foods such as ready meals, soup, etc. A further proportion goes to "food service" businesses – operators of canteens, restaurant chains, commercial caterers, and so on. The remainder is delivered to shops for sale to individual consumers.

Figure 2: Frozen Peas – Basic Activities

Figure Frozen Peas – Basic Activities



It is generally held that supermarkets account for some 80% of all food sales in the UK, so it is assumed that most peas pass through their logistics chains. These start with delivery to a product consolidator (a logistics firm), who feeds goods from a number of suppliers into a distribution centre from which they are sent out to the stores themselves. The last few activities in the sequence, those undertaken by individual consumers, will be familiar to all of us. With the exception of those lost in processing, all the peas that leave the farm pass through these activities, whether they reach the consumer via the supermarket directly, in a prepared food product or via a food-service business.

The Pea Consumption and Production System: 'Core Organisations'

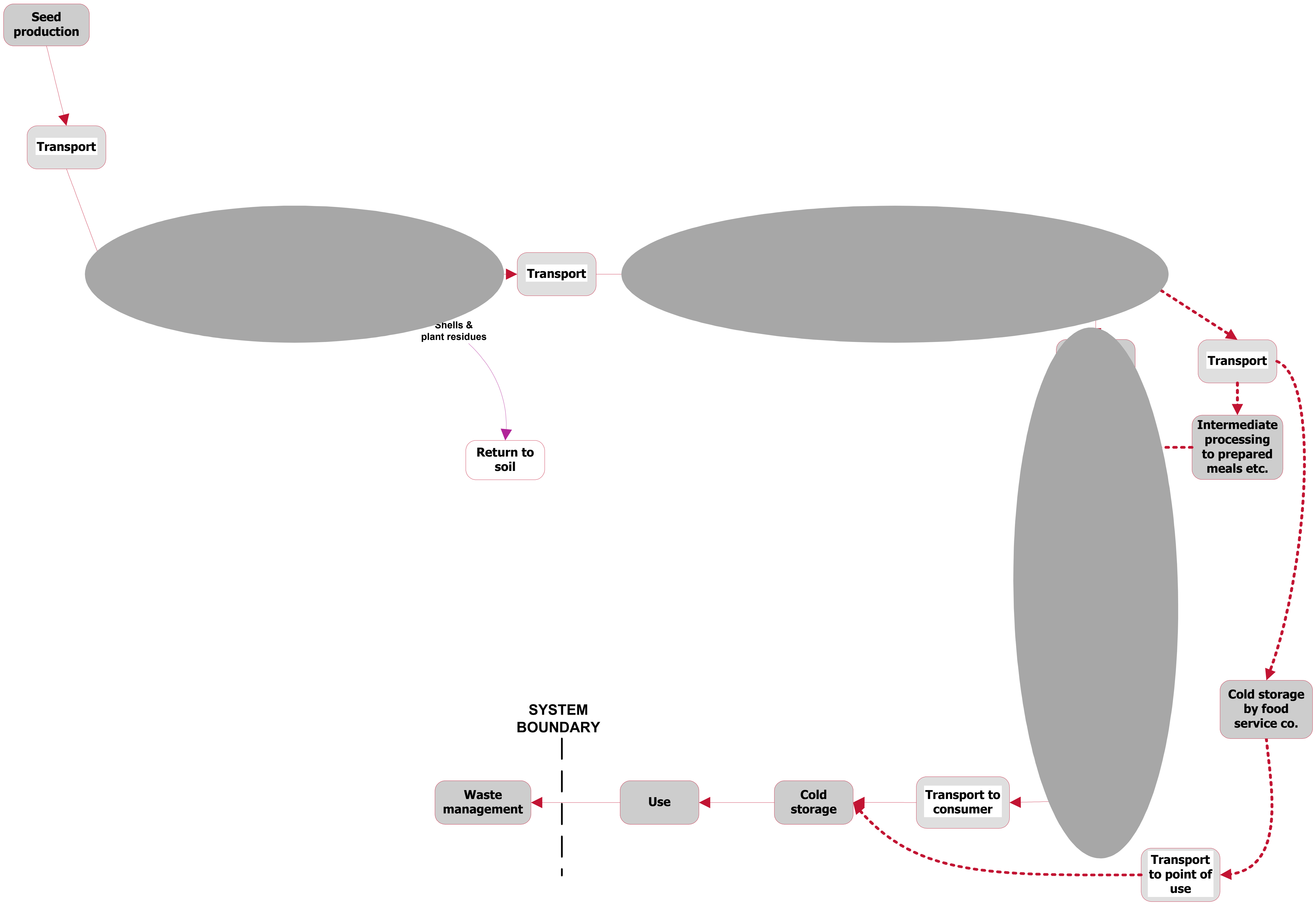
Any analysis of the implications of implementing one or another definition of sustainability must consider potential changes in the balance of power between organisations at different points in the "value chain". One of the contradictions associated with the promotion to business of, earlier, environmental and, more recently, sustainable good practice has been that it offers competitive advantage to all – 'win-win'. In the case of sustainability, different definitions have different implications for different actors: for example, stressing organic production would appear to favour *organic* producers and all those involved in moving products to consumers, while stressing *local* production would appear to provide opportunities for UK farmers and pose a number of threats to the existing food distribution system centred on chains of supermarkets with centralised purchasing.

Figure 3 shows the sections of the chain of basic activities in the pea system that are under the control of three groups. Farmers, or more accurately, "Growers' Groups" – formal co-operatives bringing together up to 50 farms and controlling cultivation of up to 4000 hectares – control the planting, growing and harvesting activities (pink shading in Figure 3). These Growers' Groups own the equipment needed for these activities and, for the most part, have in-house agronomy expertise. One large, well-known processor eats into this sphere of control by having its own agronomists work alongside producers contracted to supply its peas. There are reckoned to be some 10-15 of these Grower Groups in the UK now, and the tendency is for them to concentrate further in pursuit of economies of scale.

Moving downstream, the current level of concentration appears to be greater still. There are reported to be only three large pea-freezing operations in the UK, as well as a handful of smaller independents. Their sphere of control is shown by the blue shading in Figure 3. One of the large freezers produces branded peas under its own label, leaving the rest to cover other brands and all supermarket own-brands. (A single cannery also takes in some pea production).

Despite this high level of concentration, power seems to remain with the supermarkets, which control those activities contained within the pale green ellipse in Figure 3: the economic forces that account for this are discussed in Section 6. Supermarkets appear to have greater control over inbound logistics than processors: the latter specify times and dates at which product is to be delivered, leaving choice of haulier and negotiation over haulage rates to the Grower Group. Supermarkets, on the other hand, commonly fix all of these parameters "on behalf of" their suppliers.

Figure 3: Core Organisations



The Pea Consumption and Production System: inputs from the "Technosphere"

We now turn to consideration of the inputs and outputs that are necessary for it to function. The blue boxes in Figure 4 contain those inputs and outputs that are, in our judgement, significant for the purposes of this study. Also shown on Figure 4 are "forced" (i.e. non-rain!) inputs of water to the growing stage: we have not researched the extent of these but have assumed that water used for this purpose is drawn directly from nature rather than from the mains. This unmodified input from nature is distinguished by being shown in a yellow box.

The other inputs shown in Figure 4 all start out as natural resources in some form, but are modified by human intervention. It is convenient to think of these modified natural resources as products of the "Technosphere" whether they take the form of capital equipment or raw materials. The inputs shown do not constitute a comprehensive set: we do not, for example, show fuel inputs to transport activities – although these should not be neglected in future analysis. The inputs have been categorised to some extent according to source and type. Thus, those inputs bought in from the chemical industry are shown in boxes with yellow fill; those from the refrigeration industry in boxes shaded pale blue; those from the energy industry in boxes with orange shading, and those from the packaging industry in a box with shaded pale green. The inputs are described in generic terms because, for most, there is a choice.

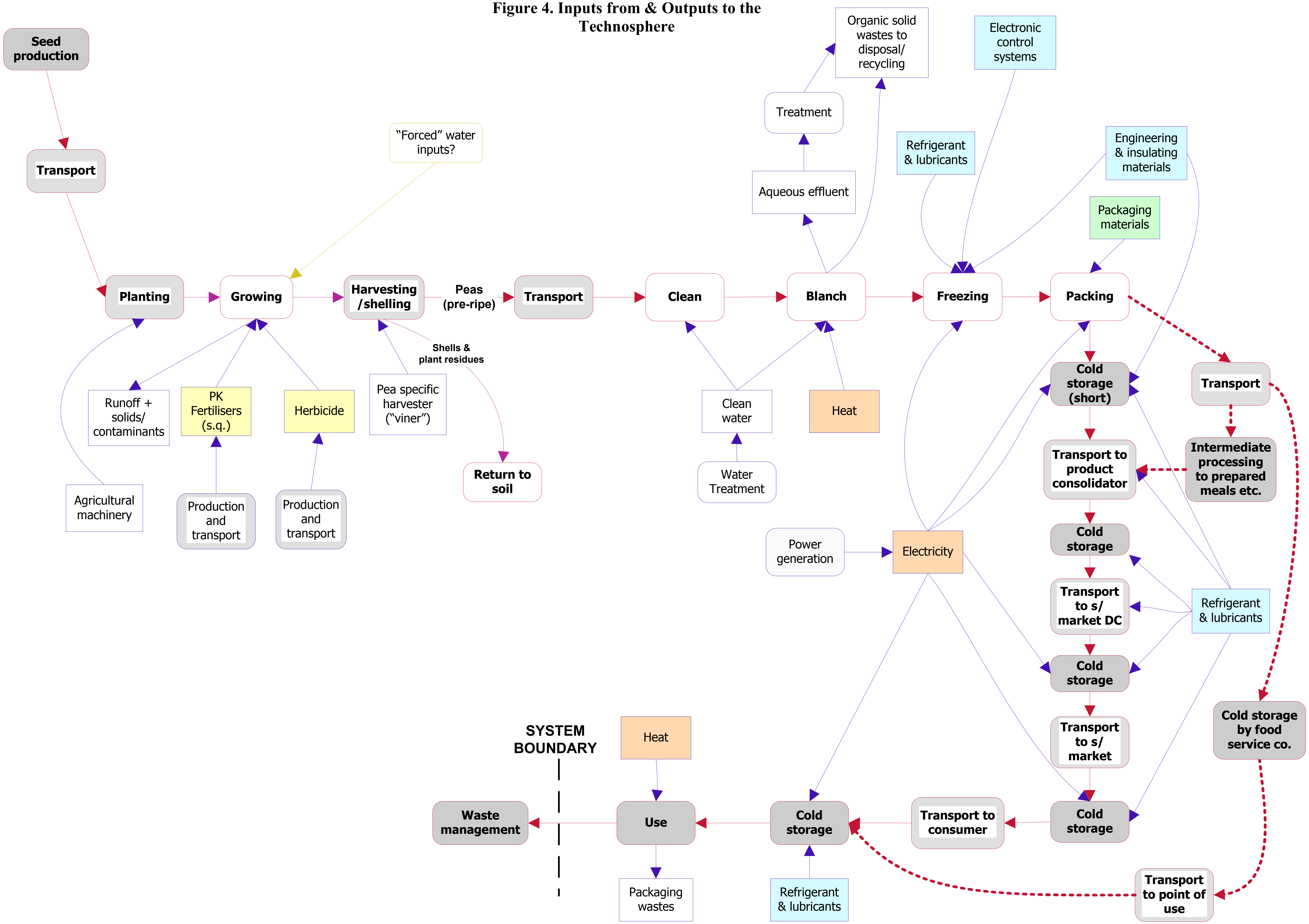
On the farm: Since peas are planted to enrich the soil they do not, themselves, require inputs of nitrogenous fertilisers. Small quantities only of phosphorous and potassium fertilisers may be used to maintain mineral balances. Selection and application rates of crop protection chemicals (herbicides, fungicides, etc.) is case-specific and is often determined by drawing on suppliers' expertise.

Into the freezer: Clean water is used in large quantities in industrial-scale food processing, both for cooking and for cleaning. It is common practice to treat mains water further to minimise bacterial contamination, either by chlorination or by UV disinfection. The need for, and importance of, heat and electricity in a process which entails first immersion of peas in boiling water followed by freezing is self-evident. Some might argue that disinfectant chemicals are a "sine qua non" for industrial food processing, but we have judged their significance to be somewhat lower in this case, partly in the light of the fact that frozen peas will receive further cooking (which should ensure fitness-for-consumption) and partly in the light of the expected scale of chemical use.

The components of the refrigeration system are clearly critical to the freezing activity. Although the consumables (refrigerants; lubricants) are shown here, we suggest that it is the equipment, enabling the compression-expansion cycle to be driven and harnessed to move heat energy, that is the critical input here. Know-how may therefore be a more important input than materiel, and some such inputs are discussed in the next section.

Through the distribution chain: In fact, the refrigeration process is critical to any frozen food system at every stage from initial freezing through to the point at which it is used, so the same inputs are shown to every basic activity (refrigeration is also used in the transport activities, of course, although not shown explicitly).

Figure 4. Inputs from & Outputs to the Technosphere



Packaging material inputs are only shown in the system map at the point where peas are packed into their sales packaging, which is most often printed plastic film but may also be waxed board. Secondary packing, such as cardboard cases, and tertiary or transit packing (shrink-wrap, pallets, wheeled cages, etc.) will be used – entering and leaving the system both at the initial packing stage and elsewhere.

Falling off the sides: The outputs highlighted in Figure 4 are wastes from the pea processing activity and contaminated runoff from farming (the latter may in fact enter the environment directly, rather than passing through some form of treatment as implied by its representation here as an output to the Technosphere). There are, of course, other commercial and industrial wastes from all the activities shown. These have not been included in the system map – partly for want of space, and also because they are judged to be of less significance to a study of food systems' particular characteristics.

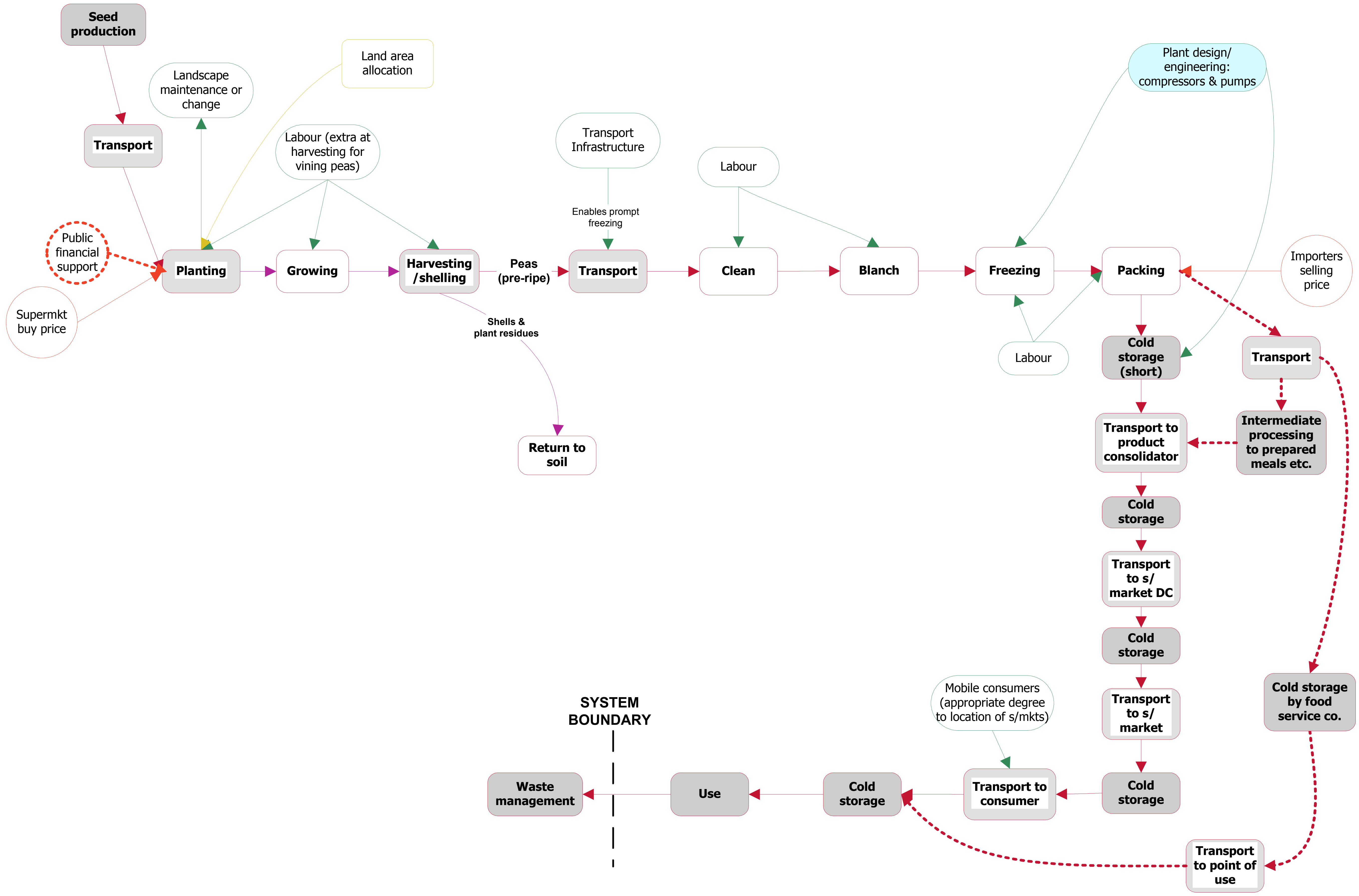
Socio-economic Inputs and Structures

While physical resource flows are needed for the operation of the frozen pea system, a range of economic and societal inputs are also necessary. It is possible to identify a variety of these. Some, such as labour, can be seen as a potentially substitutable input, exhibiting differential mobility and different degrees of fixed/flexible supply, depending on the labour class involved, the levels of skill (and therefore training) involved, and the terms and conditions for hiring labour. The supply of labour does not typically nowadays have significant implications for natural resource consumption. Others are decisions, such as the decision to allocate land to agriculture or the decision to build transport infrastructure. Decisions like the latter obviously lead to natural resource consumption, so that the provision of road transport infrastructure could be represented as an input of built road from the Technosphere to the pea system. However, it is widely acknowledged by workers in the field of life cycle assessment (LCA) that the inclusion of capital goods in product systems makes no significant difference to the results of LCAs, because the impacts associated with the production of these goods is spread so thinly over their lifetime use. On the other hand without decisions to build the transport infrastructure in something like its current form the pea system as shown here could not function. In particular, we suggest that in this case the road network is essential for fulfilment, by a small number of processing centres, of the short time-to-frozen commitments that appear to be common in the industry. Further exploration of this aspect of the system may well be worthwhile as the project moves forward.

Figure 5 shows the chain of basic activities in the system with inputs from and outputs to society shown in green "boxes" and economic "inputs" (forces might be a better term here) in orange circles. Labour inputs at the farming and food-processing stages are shown, because the existence of jobs in rural areas is a significant factor to some parties in the sustainability debate. It seems, however, that labour inputs to pea cultivation are not very different from labour inputs to the cultivation of other crops, although the need for very rapid collection at harvest time requires some additional labour for a short period on any individual farm (Grower Groups stagger planting across the land they operate so that harvesting continues for a period of weeks).

Land allocation is a direct input to the system from nature (denoted in the system map by a yellow "box") but has been included as a socio-economic input because the *decision* to allocate the land is seen as a significant factor, as much as the occupancy of land by pea cultivation.

Figure 5. First-order Socio-Economic Inputs



The importance of compressor and pump technology to the refrigeration process has already been mentioned, and is shown here. Consumer mobility is also an important factor, although the penetration of the market for vegetables by the frozen form pre-dates the move of supermarkets to out-of-town and edge-of-town locations, so the car-bound consumer is not judged to be critical.

Only three economic factors are shown, all inputs (support payments, supermarket buying price and the price of imported frozen peas). Clearly the balance between what supermarkets, as buyers, are willing to pay growers for their product and what growers could receive for alternative crops would be expected to be an important factor influencing crop selection. The support payments available to growers for combining peas and field beans amount to some £260 per hectare currently. The selling price of combining peas is in the region of £80 per tonne, with crop yields of the order of 5 tonne/hectare, so that a hectare of this alternative crop may yield some £650 in income, of which 40% is support payment. This alternative might reasonably be expected to set some lower limit on the price to which supermarket buyers can drive frozen pea growers down. The price at which imported peas are available imposes an upper limit on the price that growers and processors can obtain from supermarkets, although it has been reported that the supermarkets' desire to be seen to be supporting UK farming may allow growers in this country a slight premium for peas destined for direct sale to consumers. It should be noted that intermediate processors and food-service businesses, with lower public profiles, have no such sensitivities.

A further crucial economic input (though it is not shown in the Figures) is the availability and access to finance. Modern market economies only exist according to the precondition that there exists a flow of investment capital and credit facility to 'lubricate' the productive system, enabling production to take place in the absence of, but in the expectation that, consumption will follow in the future. A working and workable integrated financial system is often taken for granted and rendered invisible in resource-flow models. History shows however that when financial systems enter crisis this can have catastrophic and often amplifying contagious effects across the system.

Economic outputs have not been included in the system map. While they can readily be identified (payments to workers, business profits, taxes), investigating their relative significance (say in terms of which organisations get which proportions of the selling price of a pea, and how much is profit in each case) would require more detailed research.

CONCLUSION

The map of the UK *frozen pea* system in this paper has been presented not just in terms of its materials flow but also of the particular institutional, technological and economic factors that influence and indeed structure it. As such, it presents the opportunity for further research into the implications for the system and the actors within it of working towards different definitions of sustainability. In drawing up a description and graphic representation that cover all elements of the frozen pea system from seed to consumption but are at the same time reasonably concise, some judgment and selectivity has been essential. This selection process has endeavoured to focus on factors (which we believe can usefully be classified as inputs or outputs) that either enable or constrain the system as it operates now. It has tried to pick out technological knowledge, societal characteristics, resource flows and economic conditions which, if changed significantly or taken away, would cause peas – if they were grown at all – to be handled very differently.

The continued survival and reproduction of the UK frozen pea system we have described depends on a number of conditions that are both social and technological. It is clear that, at the level of system actors, if there is to be one actor with a central structuring role and qualitative asymmetric power it is Unilever. This is especially important when we look at the sources of knowledge in the system. Unilever's expenditure on R&D and its ability to mobilise knowledge of agriculture, the freezing process and the logistics of pea distribution make it the key location for any innovation within the system (or the breaker of other innovations that might adversely change the system). Unilever is thus the key agent in producing and interpreting knowledge about 'sustainability', in the sense that it is Unilever that is the agent that considers what is worth investigating and acting on to bring about more 'sustainable' pea production. Unilever's interest in sustainability is connected with the maintenance of its power in the pea system. So far, this interest in sustainability has been confined to an investigation of agricultural practices of pea-growing. This can be seen either as the 'first step' in an examination of the sustainability of the pea system as a whole, or as an attempt to define sustainability as just being about agriculture.

However, as we have sought to show, there are a number of features of the pea system that deserve investigation if we are to think more systemically about sustainability. These could be called the 'bottlenecks'/'pinch-points' that would have to be? subjected to change for any sustainable reconstruction of the chain; they are: 1) The influence on the system of the notion that peas have to be moved from 'field to frozen' in a relatively short period of time; 2) The central position of the pea in the everyday eating habits of the UK populace; 3) The centrality of the refrigeration process, at numerous sites as well as in transit.

However, if we can identify *one* element of the system that structures the rest of it, it is the transport infrastructure for the necessary *prompt freezing* of the pea. This in turn is set by the instituted consumption practice that puts the frozen pea as a cheap, year-round convenient component of green vegetables in the average UK diet. Sustainable reconstruction of the chain might depend on basic changes in some of the current system conditions. These include:

- The possibility of higher prices (necessary if all peas were to be 'organic');
- A shift back to *seasonality* for the vegetable (a contrary trend at the moment for virtually *all* fruits and vegetables);
- The assumption that delivery of peas requires long food chains can be altered.

All of these would certainly require some change in the place of the pea in UK diets. Organic advocates would expect that some of these changes would be necessary throughout UK agriculture and food consumption practices. However, there are other more 'neo-industrial' strategies that can also be imagined. In this strategy, you could envisage *new* varieties of peas that travel better, overcoming the transport/prompt freezing bottleneck. This might come from better knowledge of the pea genome and the ability to use that knowledge to create or engineer new varieties. This would then reduce the need for peas to be grown very near to freezing plants thus opening the possibility of changing the economies of scale of the industry, opening up the possibility of local agriculture and local freezing. Such ideas are purely speculative at the moment.

Further research might also be conducted into the underpinning structures and meanings that inform consumption as *practice* (Warde 1996) and which then have an iterative or complicit effect on production. We have already identified that pea consumption has a geographic structure, peas being a 'staple' of the UK diet. We can also conjecture social class, age, and 'occasion' dimensions of the structuring of pea-eating practices. We have identified the pea as a 'stand-by' freezer food, therefore integrated and dependent for its existence and meaning on a whole range and combination of household domestic appliances, notably freezers and cookers. We can also conjecture that peas are eaten primarily as a complement to other, equally taken for granted foods (chips, fish, chicken, burgers) as staples of the UK diet. Perhaps they are more likely to be eaten as a mid-week rather than weekend meal, as a children's rather than an adult meal, and for everyday occasions rather than special candle-lit dinners. All these ways of appropriating peas into the mundane everyday lives of ordinary people have profound impacts on the way peas have come to be used, understood, bought and stored (and thus produced, and most importantly, transported). Furthermore, producers do not passively accept these structures of consumption, rather, through their marketing 'segmentation' and communication strategies they proactively seek to reinforce stratified consumption patterns. Alternatively, producers may use product differentiation and product variety generation strategies to push appeal into new segments and ratchet up total consumption. Thus, although peas have arguably not been subjected to the same variety generation processes as the 'humble tomato' (Harvey *et al.,* 2002), we are nevertheless familiar with the distinction, exaggerated by producers, between the ordinary 'garden pea' on the one hand and the special '*petit pois'* on the other.

Giving peas a chance to be the product of a sustainable system clearly requires consideration of more than agricultural practices – it focuses attention on the intimate connection between consumption and production and the way this connection 'crystallises' into particular technological practices across the system. Innovating to transform these practices is essential for sustainability.

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