Food production and food procurement in the Bronze Age and Early Iron Age (2000-500 BC)

Hingh, A.E. de

3 Models of the intensification of agriculture

3.1 Introduction

In the previous chapter aspects of Late Neolithic, Bronze Age and Iron Age agrarian societies and the main topics of the scientific discourse on agriculture and agrarian land use were presented. Some recurring uncertainties seem to dominate this discussion. The changes that the agrarian regime supposedly underwent in this period are difficult to grasp. We might assume a shift from an "agriculture itinérante" (or shifting or swidden cultivation) to a more intensified agrarian system. If we do so, though, the nature and the course of this supposed process of agricultural intensification remain rather enigmatic to us.

In the present study of agricultural change and land use, the concept of intensification of agrarian production, apparently forms a key concept. We should note, however, that when archaeologists and archaeobotanists use the concept of intensification of agriculture, they often refer to essentially different phenomena. As a corollary, difference in the use of the concept ("what exactly intensification is") and difference of opinion ("whether intensification really took place") are easily confused.

In section 3.2, I will present the definition of the concept of agricultural intensification as employed in agricultural economics and the evidence for it in the archaeological and botanical record. In section 3.3, the Boserup model of agricultural intensification, referred to in the previous chapter, and the possibilities of this model for archaeology, will be critically examined. In section 3.4 an alternative approach is introduced, i.e. a broader approach of intensification of agricultural production, developed by the anthropologist Morrison. Finally, I will present the way in which the major elements of this latter approach, combined with elements of Boserup's model and the definition from economics will be adopted in this study of agricultural change (section 3.5).

3.2 Extensive and intensive agriculture

Extensification and intensification of cultivation appear to be key concepts in the discussion on agricultural regimes in Bronze Age and Iron Age society. There should be little difference of opinion on the definition *sensu stricto* of extensive and intensive agriculture, as this is a concept drawn from agricultural economics. The most common use of these two terms is to refer to the quantity of other resources that combine with a given amount of land (Ellis 1988, 196). These other resources can be labour (family members or draught animals), implements, manure, buildings, etc. In this definition, a small area farm size (i.e. a farm with a small area of arable land) combined with large quantities of other production resources, is referred to as intensive cultivation. In a modern, Western context the use of large quantities of fertilisers or pesticides and herbicides can intensify the agricultural productive process. Extensive cultivation refers to a large area farm size (i.e. a farm with a large area of arable land) that is combined with small quantities of other resources (mostly labour). We should note that some economists refer to "land intensive cultivation", meaning exactly the opposite - a large quantity of land compared to other resources (Ellis 1988, 196).

By definition, the notion of extensification or intensification of the agricultural productive process requires reference to a constant (Morrison 1994, 115). Intensification of agricultural production refers to an increase in the productive output, whether per unit of land, or per unit of labour or technology. Extensification refers to lower returns per area, or per unit of labour or technology. Thus, in theory, intensive systems are not only those with a higher output from the same amount of land by means of more input of labour or other resources, but also those with a consistent agricultural production from a smaller plot of arable land (i.e. a relative increase per unit of land) with a constant input of labour. When the amount of land decreases and production remains on the same level with the same input of other resources, this should also be interpreted as a form of intensification although none of the authors consulted notes it in this way.

Extensification of agricultural production:
- Increasing amount of land, equal input of labour and/or other resources (technology)
- Equal amount of land, decreasing input of labour and/or other resources (technology)

Intensification of agricultural production:
- Equal amount of land, increasing input of resources (technology) and/or labour
- Decreasing amount of land, equal input of resources (technology) and/or labour

Agricultural intensification is not necessarily an absolute increase or expansion, but it can be part of it. Intensification and also extensification are thus relative terms. It is useful to draw a distinction between intensification and expansion, for a better understanding comparable to the difference between concentration and amount.
Expansion as a concept is a totally different thing and can take various forms. A general expansion of the area under cultivation and/or pasture takes place when, for example: "agricultural output is increased simply by increasing the area sown to crops, or the number of livestock kept" (Grigg 1992, 3). Of course, agricultural change may involve both intensification and expansion, and an increase of agricultural production can take many forms, of which intensification and extensification are but two expedient responses (Morrison 1996, 587; van der Veen/O'Connor 1998, 129).

Evidence of agricultural intensification in archaeobotany
As we saw in the previous chapter, different cultivation strategies can be identified in the archaeological as well as in the archaeobotanical record. When referring to agricultural intensification, several authors tend to use the concept of intensification *sensu stricto* as defined above. For example, in the Oxford Companion to Archaeology: "agricultural intensification usually means a greater input of resources — especially labour, into a given area of land, or in other words, a high input, high output system. The appearance of new agricultural techniques (like the introduction of the animal-drawn plough) in the archaeological record is often interpreted as evidence of intensification" (Nesbitt 1996, 20). Van der Veen and O'Connor (1998, 128) put it this way: "intensive agricultural systems are those where the input per area and the return per area are high, but the return per capita is low, e.g. a horticulture regime". In her historical and archaeobotanical study of Late Precolonial Southern India, Morrison uses the following description of intensification proper (=*sensu stricto*): "in agricultural production, intensification proper is the process by which the yield per unit land and/or labour of an existing resource base is increased. This may take the form of increased investments in practices such as ploughing, seed bed preparation, weeding, transplanting, manuring or the construction of soil and water control facilities — certainly such facilities are the most archaeologically visible product of this strategy" (Morrison 1996, 587).
In archaeobotany, the evidence for agricultural intensification is often found in the introduction of newly cultivated species. Nesbitt refers to the spread of maize into the lowlands area of Mesoamerica during the Formative Period (2500 BC onward), or of sorghum and cotton into India in the second millennium BC (Nesbitt 1996, 20). Harding finds evidence for agricultural intensification in the Late Bronze Age in Northern Europe in the introduction of new species and the broadening of the range of cultigens, like millet, pulses and gold-of-pleasure (Harding 1989). Also Kroll points to intensifying agricultural changes in Central Europe in the urnfield period. He mentions a larger diversification of species, more attention for specific demands of the single species, cultivation on small plots of land, and increasing handwork with sowing, caring for the plants and working the harvest. These changes are related to the introduction of a characteristic combination of crop species that all require intensive cultivation, like millet, lentil, and poppy (Kroll 1997, 110). Van der Veen, in her botanical study of crop husbandry regimes in Northern England between 1000 BC and AD 500 distinguished, by analysing her seed assemblages, two different contemporaneous groups of sites representing two different types of agricultural systems. In group A, the crop plants, emmer wheat, some spelt wheat, barley and arable weed species indicative of intensive soil working (digging, ploughing), weeding and manuring, point to the presence of intensive small-scale agriculture at these sites, where much attention was paid to manuring and to intensive soil working (both typical for a system of intensive agricultural cultivation). The group B sites are characterised by spelt wheat, barley and weed species indicative of limited soil working and manuring, and represent the introduction of a system of a larger scale production or arable expansion, in her view an extensive cultivation regime. The strong contrast between the two groups can be interpreted as representing different levels of energy spent per unit of land, or in other words various levels of intensification (van der Veen 1992, 147-148).
These differences in arable production are related to different types of settlement (defended/non-defended), social structure of society (different degrees of centralisation) and tribal affinity. They seem to make up part of a number of developments, like an increase of population and increasing social stratification in later prehistory and the Roman period (ibidem, 156; vdVeen/O'Connor 1998, 132-3). The important role of manure in systems where crop yields need to be maximised would seem obvious enough, but as van der Veen notes, not much research has been done on this subject. She goes one step further herself by stating that the existence of intensive cereal production might also be confirmed by finding a correlation between sites with emmer and small fields with evidence for manure.

Demonstrating extensive cultivation in archaeobotany
It is more difficult to find any traces of extensification of agriculture in the archaeological record. Extensification of the agricultural production is, by definition, a relative extension of the area under cultivation without expanding the existing labour force or other input. Extensive agricultural

systems have a high return per capita (as relatively few people are needed), as in sheep rearing or large-scale cereal growing (Van der Veen/O'Connor 1998, 128). Kroll (1997) describes an extensive cultivation regime on the löss plateaus of Central Europe, with large surfaces of land under cultivation, often with one single (mostly winter-) crop, like einkorn, which is undemanding. In his view, the Early Bronze Age especially, is characterised by such an extensive agricultural regime. The consequence of a similar system can be demonstrated in the archaeobotanical record, by the presence of large numbers of (winter cereal) weeds (Kroll 1997, 110). Van der Veen proposed in her study of crop husbandry regimes in Northern England that spelt, especially, can be associated with the poorest soil indicators, suggesting that this crop was grown under more extensive conditions than wheat (van der Veen 1992). Also Roman agriculture with its large-scale, "industrial" production regime of the *villae*, is often related to an extensive system. If a farming community decided to expand by increasing the area under cultivation without an associated increase in available traction, manure or labour, this would inevitably result in a gradual deterioration of the soil conditions in the fields.

3.3 Boserup

In the previous chapter we already referred to the influence of the so-called frequency of cropping-model of the Danish economist Boserup in the archaeological debate on agricultural change (see figure 2.14). This scheme offers an operational definition of intensification, in terms of a growing permanency of exploitation of the same arable. The central assumption in this model is that intensification proceeds along a single course, characterised by gradual stages of increasing frequency of cropping, i.e. in the shortening of the fallow periods. Population growth is regarded as the autonomous factor (the 'prime mover') making for a steady intensification in agriculture, which in turn brings a whole host of technological and sociological changes in train (Boserup 1965; Morrison 1994; 1996).
Boserup's model of population growth and agricultural intensification has been without doubt, the most influential formulation of the problem in archaeology as well as in other disciplines, like anthropology. In this section, several aspects and assumptions of the model will be discussed. That is, the causal factor of population pressure to agricultural intensification, the technological aspects associated with the process of agricultural intensification and the unilinearity of the path of intensification in this model, expressed in an increasing frequency of cropping. For this discussion, I made much use of two papers by the American anthropologist Morrison (1994, 1996), where the Boserup model is re-examined.

Population pressure
Boserup's departure point in her 1965 publication was the revolutionary statement (for those days) that demographical growth as an independent variable causes intensification of agricultural production. She can be placed in the centre of a virtually classical debate on the interrelationship between population growth and food production. There are two fundamentally different ways of approaching this problem. There are those who suppose that changes in agricultural conditions (e.g. available technology) determine the rate and extent of population growth and those who believe the opposite (see also Harding 1989, 178). In Boserup's view, population explosion was a change in basic conditions which should be regarded as an autonomous, independent variable which is a major factor determining agricultural developments. The explanation of population growth is not to be found in improved circumstances of food production, but is related to e.g. medical developments or political circumstances (Boserup 1965, 12). Until then, the reverse relation had always been demonstrated, i.e. that changes in agricultural conditions affect the demographic situation. In this 19th century, Malthusian perspective, population growth was seen as the dependent variable that was determined by preceding changes in agricultural productivity. These changes were explained in their turn as results of factors like fortuitous technological developments and imitation.
By distancing herself from that traditional point of view, Boserup hoped to offer a fuller understanding of the historical course of agriculture and the development of patterns of techniques of cultivation and social structures of non-western agrarian communities. She thereby rejected the "pessimistic" Malthusian concept that population increase (especially in development countries) by definition would lead to exhaustion of the arable land, famine and moving away of groups to other places. On the contrary, in her perspective, demographic growth would cause local communities to change their cultivation methods to guarantee or even increase the fertility of the arable land.
For numerous different regions in Atlantic Europe a demographic increase is perceived particularly in the Late Bronze Age. As mentioned before, a demographical expansion possibly took place in the Late Bronze Age and the Early Iron Age in the Lower Rhine region, as suggested by Roymans and Kortlang (Roymans/Kortlang 1999). Interestingly, they related this population growth with an extensifying cultivation regime, in Boserupian terms a lower frequency of cropping system. Besides, we should note that a possible population growth is not as clearly demonstrated everywhere (see section 2.2). A supposed increasing demographic density in the Late Bronze Age in the Lorraine region is related to changing land use and intensifying agricultural practices

(Blouet et al. 1992). Also for numerous other regions, like in the Jura (region of the river Ain) an increase of population is assumed from 1000 to 600 BC (e.g. Pétrequin 1992).
In general we should have little problem assuming population growth. Besides, the majority of archaeologists assume a significant relation between demographic explosion and changes in agricultural land use. It is important however to note that the way this relation is characterised is totally different, be it extensification (Roymans/Kortlang 1993; 1999), intensification (Blouet et al. 1992; Barrett 1994), the exploitation of new marginal grounds (Champion et al. 1984) or a mere expansion (vdVeen/O'Connor 1998, for the late Iron Age).

Land use aspects in Boserup's model of agricultural intensification
In Boserup's model, agricultural land use and the fertility of land should not be seen as an exogenous, unchangeable condition determined by environmental factors, but as a variable strongly related to population growth and changes in agricultural cultivation methods. The increasing frequency, with which arable land is cultivated in an intensifying agricultural system, takes a central position. For the benefit of the analysis, Boserup discerns five stages in order of increasing intensity (see also figure 2.14):

1. Forest-fallow cultivation, with a fallow period of 20 to 25 years
In this cultivation system plots of land were cleared in the forest each year and sown and planted for a year or two, after which the land is left fallow for a time sufficiently long for the forest to regain the land.
2. Bush-fallow cultivation, with a fallow period of 6 to 10 years
During the shorter fallow under this system the land is gradually covered with bush. The cultivation period may vary from one to two years, like under the forest fallow, or it may be as long as the fallow period, i.e. c. 8 years. The first phases are also labelled as long-fallow cultivation, or shifting cultivation.
3. Short-fallow cultivation, with a fallow period of 1 to 3 years
In the short fallow period of a few years under this system, only grasses regenerate before the farmer returns to the same plot of arable land.
4. Annual cropping, with a fallow period of several months
Under this system the land is left uncultivated for only several months; it includes systems of annual rotation.
5. Multi-cropping, with a negligible period of fallow
In this most intensive cultivation system, the planting of new crops takes place shortly after the harvesting of the preceding one.

Morrison severely criticizes the way in which in Boserup's model, "growing populations drive agricultural change along this extensive-intensive continuum of increasing cropping frequencies" (Morrison 1994, 116). In her view, the measure of cropping frequency seriously misrepresents the organisation of actual agricultural strategies and of their change throughout time. It only brought diverse production strategies (from so-called primitive ones such as tropical swidden cultivation, to modern Western industrial agriculture) together in a single analytical scheme (Morrison 1996, 584). The operational definition of intensification as cropping frequency reflects Boserup's focus on continuous and gradual change. The problem with fallow length as a measure of intensification lies finally not in its inappropriateness, but in the fact that fallow length constitutes a univariate measure of a multivariate phenomenon and can provide only a partial index of that phenomenon. In Morrison's view, Boserup's fallow length categories continue to be inrightfully used in archaeology as an *a priori* universal sequence of developmental stages (Morrison 1994, 136-7).
However, two things should be noted with regard to the critique on this scheme. First, Boserup explicitly stresses that, in primitive types of agriculture, no sharp distinction between cultivated and uncultivated land is made. This means that it is impossible to distinguish clearly, as is traditionally done, between the creation of new fields and the change of methods in existing fields (cf. ideas of Champion et al. 1984, cited in section 2.4). That is why Boserup emphatically rejects the traditional, strong dichotomy between the creation of *new* arable fields and intensification on *existing* fields, by introducing new agricultural methods. She considers this rigid distinction as a typical Western, 20th century way of describing an output increase due to population increase. That is why she introduces the model of gradual change in frequency of cropping.
It remains unclear in Boserup's work, however, whether the frequency of cropping scheme demonstrates a sequence from extensive cultivation to intensive cultivation throughout time or whether a contemporality of these stages is also possible. Different systems may well have been in use at the same time. And, if the constructed progression of change in the Boserup model is based not on analyses of change throughout *time* but on the arrangement of contemporary peoples into an evolutionary scheme, it seems worthwhile to consider evaluating this proposal against what we know about the past. But, as Morrison demonstrates, Boserup sees the coexistence of various systems as an evolutionary transition period of agricultural change not yet completed, rather than as a delibarate economic strategy (Boserup 1965, 56-59, Morrison 1996, 585).
Second, it is important to note that Boserup stresses that the deliberate choice for certain fallow systems was no deter-

ministic adaptation to certain soil types or climatic circumstances. In other words, a choice for a low frequency of cropping should not be seen as an adoption to infertility of the arable soil. She prefers to show the flexible inventiveness of agrarian communities. Fertility of the arable soil would be the result of the employment of intensive production methods and not vice versa (Boserup 1965, 19-20). This is an important point of view, which, in archaeology and archaeobotany, is not always paid sufficient attention to. In the previous chapter, for example, we referred to Roymans who sees the infertility of the sandy soils in North-Brabant as an exogenous initial condition or even an unchangeable, deterministic factor that would, by his account, explain the extensive agricultural system in the Iron Age. Even so, there are far more examples of (esp. archaeobotanical) studies where the absence or presence of certain crops is related to the nutrient availability of the arable soil. I agree with Boserup (and her followers) that soil fertility should be treated explicitly as a variable closely associated with changes in agricultural methods and techniques, introduced by "inventive" people.

Technological aspects

The Boserup scheme assumes a strong association between the phases of cropping regimes and the classes of agricultural tools and agricultural techniques (e.g. manuring) that were used. The type of tool needed in a given context depends on the system of land use (cq. fallow systems). Technological evolutions are determined by the prevailing agricultural practice. This implies that under a forest fallow cultivation system where plots of land in the forest were cleared each year, large trees were felled with an axe or burnt down on the root after ringing. Low vegetation was burnt down, and the remaining ashes sufficed to secure high yields. The use of the plough was not necessary in this regime. We noted before that using the prehistoric plough (or ard) might even have been impossible in a forest fallow system because of the remaining roots and trunks present in the fields (see section 2.4; Fokkens 1986). Opinions on this matter differ. Boserup points out that the use of the ard (the so-called *Hakenpfluge* or *Zoche*), i.e. the lighter animal drawn implements that we know from the (Late) Neolithic, Bronze Age and Iron Age society, did serve in slash and burn economy (Boserup 1965, 24 - footnote 1).
In the bush fallow system the hoe is introduced as an additional implement. The herbs that flourish during shorter fallow periods can be removed with this implement. Additional fertilisers like burnt or unburned leaves, turf, mixed with the topsoil by the hoe, were used in this system. In a system of shorter fallow periods where bushes and trees do not regenerate and only grasses occur as they are resistant to fire and to the use of the hoe.[5] The use of the plough thus becomes inevitable and possible at the same time. At the stage of intensive land use, several types of fertilisation were simultaneously in use: included were green manuring, marling, compost, household waste etc. Manure from the droppings of cattle and human waste was also used as fertilisers. In a multi cropping system, irrigation techniques and other land improvements, like terracing are introduced.
The Boserupian association of technological innovations with regard to agricultural implements and an increasing permanency of land use seems to be justified. Archaeologists, however, should be careful of adopting elements from this scheme too easily. When we recover archaeological ard traces or plough marks, for example, it may be tempting to look up the matching frequency-of-cropping stage in the Boserup scheme and take in all other aspects associated with this stage. This passes over the possibility of the coexistence of agricultural regimes.

Labour input

According to Boserup, changes in the length of the fallow period are also related to the labour input per crop hectare, e.g. the forest fallow system is a non demanding system yielding a good crop with little input of labour. No labour is needed for land preparation, weeding, manuring or for the care of draught animals in a forest fallow system. After the tree-felling and a superficial clearing, the fire then does all the work, and there is no need to remove the remaining roots, which is a demanding, labour intensive activity when preparing permanent fields. Evidently, the time needed for forest fallow cultivation depends on the climate and the type of the original vegetation, and also the design of the axe, but it is a relatively fast regime. It takes more time to hoe and weed one hectare than to superficially clear one hectare of forest with axe and fire.
Experiments with regard to tree-felling and slash-and-burn have been performed by Troels-Smith and Iversen in the 50's. The experiments were prompted by reactions to Iversen's seminal paper (1941) "Landnam I Danmarks's Stenalder" (see also chapter 2). Doubts were voiced as to whether it would be possible to clear areas of forest using flint axes so that the effects could be recognisable in pollen diagrams. It was demonstrated that one person would need 36 days to clear one hectare. It appeared that it would not have been such a great problem in the stone age to clear relatively large surfaces of woodland (Troels-Smith 1990, 75). For that matter, it furthermore became clear that the burnt plots of land yielded a far better harvest than the unburnt plots that were worked with the hoe.
In a bush fallow system the bush is cleared, which takes less time. However, hoeing and weeding demand more effort. In short, the transition from forest fallow to bush fallow results in a lower output per man-hour of labour input. Intensifica-

tion of the bush-fallow system by lengthening the period of continuous cultivation of one plot of land (for example, 8 years of cultivation, 8 years of fallow) results in a decreasing need of clearing. However, it demands much more careful clearing and very labour-intensive methods of land preparation, manuring and weeding.
Short fallow agriculture virtually implies the practice of ploughing. It is often assumed that the introduction of the plough increases the output per man-hour. However, Boserup questioned this assumption: ploughing is hard work and it also takes the extra care for the draughts animals.
The amount of labour and man-hours required for ploughing has been assessed by experimental archaeology. According to most authors, 4000 m^2 can be ploughed and cross-ploughed in a day (Fowler 1983; Steensberg 1986, 143; Reynolds 1987). Hansen noted that ploughing with an ard (Dostrup type) with two trained oxen took place at a speed of 3,6 - 4,3 kilometres/hr. (Hansen 1969). This has lead Brinkkemper to demonstrate that, assuming that prehistoric ard marks were c. 25 centimetres apart, 40 kilometres of furrows for one hectare were needed. This means that ploughing and cross ploughing of one hectare requires c. twenty hours or two working days of continuous ploughing. He thinks anthropological data from Yemen are more realistic; here it was observed that ploughing with an ard took 3,3 days per hectare with a span of two oxen (Brinkkemper 1991, 152).
Although it is hardly possible to compare the quantative figures taken from experimental archaeology and the evidence put forward by Boserup we can make some assumptions. For local groups with large herds of animals, that would pay much attention to collecting manure, making compost and distributing it on the fields, the yields of short fallow or annual cropping per man hour are higher than for forest fallow systems. Boserup assumed, though, that growing populations would not so easily change their cultivation system drastically to produce additional food by increasing ploughing or weeding, because of these extra labour requirements and the related diminishing returns on labour (Declining Efficiency). She would expect that only a part of the available land that used to know a fallow period would be selected to be cultivated annually. In this way the additional labour was used to change the cultivation regime in only *part* of the total territory.
Morrison opposes the idea of these so-called disadvantages (increased labour and declining efficiency) of intensive agriculture introduced by Boserup. These disadvantages would ensure that such models of production would be adopted only when strictly necessary. The concepts of an increased labour input and a declining efficiency of this labour are Western, 20th century centred, and thus, in her view, inapplicable to archaeology. The same goes for Boserup's related assumption that producers would always exert the minimum effort possible to meet their needs (Law of Least Effort) and, thus, the most labour-extensive regime possible would always be employed.

Operationalising the frequency of cropping-model in archaeology and in archaeobotany
The Boserup model is no doubt very attractive to archaeology. This is demonstrated by the numerous examples where the model is incorporated in descriptions of agricultural intensification and social change in prehistoric society.
Barrett (1994) cites Boserup in his description of long-term developments in British prehistoric society. He regards the transition to a short-fallow agriculture from the beginning of the 2nd millennium BC as a change towards a different organization of labour, a greater investment of agricultural technology and finally a more tightly drawn community whose members were able to sustain their tenurial claims over a specific area of land from one generation to the next. In this way, according to Barrett, the biographies of the individual came to be tied more closely to a certain portion of land and to a more tightly defined and closed community (1994, 143-145).
Fokkens (1991) mentions the Boserupian scheme in his investigation of the developments in the prehistoric Dutch Frisian-Drentian plateau. Although he has no reason to assume that demographic pressure played any role in this area, he presumes that an agricultural intensification and an increase of agricultural yields took place, probably caused by the exhaustion of arable soils and the climatic deterioration at the end of the Late Bronze Age. Fokkens relates these developments to the introduction of the Celtic fields system (1991, 161-2).
In French archaeology, the Boserup model was also adopted to explain changes in prehistoric agriculture (Guilaine 1991, 46-7). For the sites in the region of the Lac du Clairvaux (Jura), for example, demographic pressure is employed as causal factor for the transition to a *culture à jachère courte* (short fallow) and the introduction of the plough (Lambert/Pétrequin/Richard 1983, Pétrequin 1990).

Elements from the Boserup scheme are often used in archaeology and archaeobotany, either unconsciously or implicitly, without reference to their Boserupian origin. Demographic change is almost always related to intensifying changes in land use (but see Roymans!). The introduction of the plough is often related to the introduction of short fallow or annual fallow cultivation (but see Halstead!). To some, the presence of charcoal fragments in pollen samples automatically leads to the conclusion that the agricultural system was based on slash-and-burn and therefore forest-fallow (Rösch 1996, for the Late Neolithic). In the Netherlands where house waste like fragmented pottery in arable layers is often found, (which is to my opinion, rightfully interpreted as a form of soil improvement), this phenomenon is often directly related to an intensified agricultural regime. These examples demonstrate that in archaeology, in general, there is virtually no room for the idea that a multiple agrarian system could have existed.

When attempting to operationalise the Boserup frequency-of-cropping scheme in archaeology, several difficulties are met with. For the archaeological record seldom disposes of quantitative information with regard to the location and the nature of the arable fields, the amount of hectares of arable land available or in use, the amount of fallow land and the length of the fallow period, yield figures, and the number of people working in agriculture. The demographic figures also often remain uncertain, so that it is hard to establish an actual population growth, which would after all be the primal cause for intensification.

These quantitative factors are hardly traceable in the archaeological record. However, several authors have tried to collect these and other data and import them into mathematical models (see e.g. Brinkkemper 1993, IJzereef 1981, Fokkens 1991). Due to the presence of too many unknown variables or unreliable quantitative evidence included in these models, they do not offer us more insight with regard to possible changes in agricultural systems. My departure point is that qualitative botanical data could help us better to identify agricultural regimes.

Indeed, with the use of these qualitative, archaeobotanical data regarding the nature of the arable land, a probable shortening of fallow can be demonstrated. The composition of seed assemblages can be a powerful revelation of the use of an arable field. Under a system of shifting cultivation in which fields were in use for a very restricted period there was no possibility for the development of specific crop weed communities (Groenman-van Waateringe 1979, 58). Archaeobotanists assume that it takes many years of continuous cultivation before weed communities develop. Still, it is also possible that an intensively cultivated field is less overgrown by arable weeds because of an intensive and regular weeding of the field. Such a system would result in a low number of arable weeds in the botanical record. Furthermore, it is supposed that the seed assemblage of an intensively cultivated field contains exclusively annual weeds, as perennial weeds do not have the chance to develop in a field that is prepared, worked and weeded annually for successive years (Jacomet, pers. comm; Jacomet/Karg 1996). Besides, the use of manure on frequently used arables could result in large quantities of (nitrogen-loving) weeds in the fields. An intensified cultivation regime as described above implies a form of (systematic) manuring. The assortment of arable weeds could point to this agricultural practice, for certain types of arable weeds do not grow on fertile soil, while others, on the other hand, prosper when nutrient availability is high. Only the species which are able to withstand the dynamics involved in the system of cultivation — annual ploughing, rapid growth of crops, mowing etc. could form stable weed communities (Groenman-van Waateringe 1979). The application of qualitative archaeobotanical data is further elaborated in chapter 9 and the succeeding chapters. In this stage I restrict myself to the remark that the use of the frequency-of-cropping model alone does not suffice to identify agricultural intensification in archaeology.

3.4 Morrison

Morrison on Boserup

In her article of 1994, the American archaeologist/anthropologist Morrison excellently demonstrates a number of weak spots of the Boserupian schema in archaeological studies of agrarian intensification processes (see above for her comments on the main aspects of the Boserup model). In short, her critique consists of the unilinear course of intensification, its technological associations and the utility of cropping frequency as an adequate measure of intensification. She also argues that population is too simply conceived as a proximate cause of agricultural change, and she has difficulties with the concepts of the Law of Least Effort and Declines in Labour Efficiency (see above).

According to Morrison, the Boserupian model is oversimplified, and cannot possibly be in agreement with prehistoric reality. Its unilineal and monolithic character is apparent from her operational definition of intensification in terms of frequency of cropping. The frequency of cropping becomes a measure of evolutionary progress along a single route of intensification. Morrison, in short, rejects, this evolutionist approach in which intensification is assumed to be a steady and gradual process, with labour inputs added continuously through time (Morrison 1994, 117, 136).

I have to disagree with some of her harsh criticism of the Boserup model. I think, as pointed out above, that Boserup herself creates the possibility of diversity and the contemporality of various stages and systems, and the moving between different systems dependent of changes in population pressure.

I think however that her critique is legitimate when it comes to the use of the Boserup model in archaeology, as the idea of a unilineair evolutionist development of agriculture in our discipline is still very much alive. Archaeologists, after all, work with large time dimensions and scales, and are often tempted to classify whole societies to a single fallowing category. In the previous chapter and in the schemes presented above it was demonstrated that some archaeologists believe that a gradual change from a shifting cultivation-like agriculture in the Late Neolithic and the Early Bronze Age to a more intensified agriculture in the Late Bronze Age and throughout the Iron Age occurred. There are many examples of the use of Boserup's model as a unilineal, evolutionist explanatory model for changes in prehistoric agricultural society — or as Morrison (1996, 585) puts it: "the influential Boserupian "measure" of intensity has also been employed to retrodict past agriculture, with early agriculture seen as *necessarily* long fallow" (see above Barrett 1994; de Hingh 1997; 1998). And as Morrison notes, this has, no doubt, to do with the fact that archaeologists, in particular, are fond of comprehensive, multicomponent, developmental schemes, perhaps because they allow us to construct an integrated picture of the past from the recovery of only a few elements of the scheme. I agree with her that the archaeological use of this scheme is often oversimplified and does not justify the prehistoric situation that was, no doubt, more dynamic.

Morrison beyond Boserup

Morrison not only criticised Boserup in her work, but also tried, though still leaning heavily on the Boserup model, to offer an alternative model of agricultural change. The most important aspect of her model has to do with the critique about the lack of emphasis on variability and diversity in Boserup's model. As noted above, Boserup sees the coexistence of cropping systems as an example of evolutionary "lag", rather than as a deliberate economic strategy (Morrison 1996, 584).

Morrison (1994, 137) nevertheless, considers it a deliberate economic strategy, citing from Netting (1977, 63-65): "the more we learn about indigenous agricultural practices, the more clearly it appears that food producers characteristically practice varieties of both shifting and intensive cultivation, simultaneously". It is a characteristic of traditional food producers to employ various cultivation systems next to each other. This would mean that, for example, a shifting cultivation and an intensive cultivation system were in use simultaneously, as in various parts of Europe where, even today, infield-outfield systems are used succesfully. In Morrison's view, prehistoric society economic systems also typically consist of multiple components, and this diversity is itself a protection against risks or uncertainty (see also Halstead/O'Shea 1989). The fact that, in anthropology, agricultural diversity is constantly observed should be taken into account and we may regard the progressive Boserup model as incorrect on this issue.

Secondly, Morrison emphasises the importance of the *process* within the stages of intensification of agriculture. While discussion on the causes and consequences of agricultural intensification has been extensive, less attention has been paid to the paths or courses that such intensification may take. When we examine actual cases of agricultural intensification, we see that this apparently single process is actually composed of multiple strategies of production differentially employed by individuals and groups. To develop an understanding of intensification as a process, it is necessary to break down the intensification process into its component elements or strategies, and begin to develop adequate archaeological methods for identifying these elements and strategies (Morrison 1994, 142).

Developments like changes in the amount and the organisation of labour and technology cannot be measured with the help of only one variable, like the frequency of cropping or the introduction of the plough, or even the introduction of new crop species, alone. Economic systems are by definition of a plural nature, i.e. are composed of several different components. The co-existence of different strategies should be considered as a deliberate economic strategy that simultaneously forms a protection against risks and insecurity (Morrison 1994, 137). Recognising and understanding a possible intensification process requires both specification of the variables and more contextual (i.e. archaeological) considerations of the specific courses of changes (see Morrison 1996, 583).

To conclude, the process of intensification is constituted of more components than what the definition *sensu stricto* or the Boserupian model of frequency-of-cropping provides us with. If we want to characterise (individual stages of) development in agriculture in prehistoric society, then variability is an important notion to add.

Operationalising the Morrison model

The Morrison model can be summarised as "an intensive agricultural system is a diverse (variable) agricultural system". In other words: intensification of the agricultural productive process is characterised by an increasing diversity within the agricultural cultivation. Morrison discerns three components which together form this intensification process: *intensification proper, specialisation and diversification* (Morrison 1994, 142-44).

This tri-partite approach bears reminiscences to a framework proposed by Halstead and O'Shea (1989). They formulated a model to study the variability of buffering mechanisms to cope with variability of (environmental) problems or change. Some might have problems with their environmental deterministic perspective, regarding environmental variability as exercising a powerful selective pressure on human behaviour. However, the approach of cultural responses to variability presented by them offers analytical potential for the diachronic investigation of long-term processes of social and cultural change and could be very fruitful to us. The practices societies employ to counteract scarcity (environmental pressure) include everything from mythology to alternative cultivation practices. They discern four groups of buffering

mechanisms: *mobility, diversification, physical storage and exchange*.
The Morrison model of diversity appears to be an ideal way to engage the agricultural changes in Bronze Age and Early Iron Age, as it captures such a diversity of elements and at the same time brings the various elements of agricultural regimes back in one comprehensive model. These elements are: the diversity in land use systems related to the various cultivation methods of various crops, a diversity of technology and the organisation of that technological diversity, and the diversity of agrarian activities, food procuring activities and food processing activities. In this way, we can combine evidence for intensification *sensu stricto* (see section 3.2), cropping frequency (see section 3.3), as well as a diversity of agricultural mechanisms or strategies in the broadest sense of the word, in order to understand and explain agricultural change. The four categories of Halstead and O'Shea as mentioned above are a convenient addition to it.
In this study I will try to employ this model of variability and combine it with the specific sets of archaeological and archaeobotanical data that are available. To do so, I will concentrate on the following aspects of agriculture with regard to the Bronze and Iron Ages:

Archaeological/-botanical evidence for intensification sensu stricto:
The detection of agricultural intensification as defined above (higher output per amount of land) by evidence for new agricultural techniques like soil management: ploughing, manuring, weeding and intensive working of the field. This will also contain a more permanent cultivation system, in a Boserupian way.
Archaeological/-botanical evidence for specialisation:
The detection of a large diversity of agricultural activities and a division of labour, and specialised activities with regard to the cultivation and processing of specific (new) crops, on one hand. On the other, communal activities, like ploughing, and (physical) storage of sowing seed and food.
Archaeological/-botanical evidence for diversification (coexistence of different strategies):
The detection of a variety of cultivation and land use systems (choice of arable fields), a (broadening of the) variety of cultigens and the introduction of new crops, possibly mixed or combined cultivation or maslins. The coexistence of horticulture and large-scale single crop cultivation, gathering of wild fruits. Food diversity and culinary diversity.
Archaeological/-botanical evidence for socio-cultural change:
The appropriation of land through the spatial organisation of agriculture: the longhouse; storage facilities: enclosed storage areas. Social differentiation through (extraordinary) food stuffs.

For the analysis of the botanical material, I chose to divide the botanical remains in three categories: crops, arable weeds and collected wild species (see also chapters 8-11). This allows for a characterisation of the different components of the agrarian regime. Recording the various crops makes it possible to dwell on the process of diversification, variation, introduction, disappearance of species, on mixtures, maslins, mixed cropping of various species and rotation systems. In other words diversification and specialisation with regard to specific cultivations. The arable weeds indicate the nature of the arable fields, the agricultural techniques and the underlying production strategies. This will reveal the possible use of manure, the length of the fallow, the working intensity, the employment of implements and the land use system. Recording the collected species will help us to reconstruct the importance of wild plants, of collecting, which can be related to variety, risk buffering and the specialisation of labour.
As soon as the agricultural regimes have been broken down into their component processes and strategies, these individual elements can be put in a diachronic perspective and we should be able to reconstruct possible changes in agriculture in the course of the Bronze Age and the Early Iron Age. The application of this analytical approach will hopefully enable us to embed the final results within the frameworks of social change as described in chapter 2.

3.5 Final remarks

On account of the specialist literature I proposed a broadening of the concept of intensification of agriculture. The traditional definition *sensu stricto* is "a larger input of resources — esp. labour — in a given plot of land, in other words, a high input, high output system". The evolutionist intensification model or frequency of cropping-model by Boserup (1965) in which the length of the fallow period takes in a central place has been very influential in archaeology. The Boserupian model represents prehistoric reality as too unilineair and does not do justice to a reality that no doubt knew far more dynamics. With Morrison (1994, 1996) I suggest a widening of the concept of intensification. Within that wider notion of intensification concepts like variability (or diversity or plurality) play an important role.
In the continuation of this thesis, the concrete results of the botanical investigations of Bronze Age and Iron Age material from settlement research allow for an identification of past cultivation regimes. The archaeo-botanical data will give more structure to the simplified image of former agriculture and will make a reconstruction at the same time more complex and more interesting. By tracing the nature of the arable fields that were under cultivation, defining the modes of agricultural production,

and reconstructing the agrarian strategies in these periods, I will be able to define possible agricultural changes. Only then we can determine whether an agricultural change took place through time in relation to long-term social and economic change in past societies and whether these processes included the intensification of the agricultural regime and changes in the appropriation of agricultural land.