INFIELD-OUTFIELD SYSTEMS
—characteristics and development in different climatic environments

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The infield-outfield system is defined, and its previous wide distribution noted. Its characteristics: efficiency, stability, and development are described. I-o farming is able to improve farmland by its ion-transfer mechanism. Finally its present survival in the North Atlantic region is explained by the system's rationality where altitude and climate restrict both expansion of infield and possibilities for ripening cereals.

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Infield-outfield farming is broadly defined as a type of farming system utilizing its area at two different levels of intensity: an intensively farmed infield and an outfield exploited at a low intensity.

Clearly, the definition is derived from an assembly of farming systems that have, no doubt, a certain historical heritage in common. The origin of infield-outfield farming is still obscure, however. In Denmark, at least, evidence produced by archaeology and palaeobiology points at an almost simultaneous emergence of agriculture and animal husbandry (Johs. Iversen 1941, 1967). A profound vegetational change that occurred during the Subboreal Forest period (3000-500 BC) points at a destruction of forest by means of axe and fire.

Wheat was cultivated, and large herds of oxen and pigs were apparently held. It seems highly probable that some animals at least seasonally were stall-fed on leaf-fodder. In some fields it is possible to distinguish between areas of cereal-cultivation and more remote, cleared areas used for fodder or for grazing, e.g. in the Barkær find, Denmark (Johs. Iversen 1967). Possibly such finds can be interpreted as indicating a neolithic origin of infield-outfield farming?

The existence in historical time of infield-outfield farming is widely documented. On the European continent, the system is at least known from Early Medieval (Schlicher van Bath, 1963). In Germany the infield was termed »Dungland« (fertilized land), the outfield »Wildland« (when alternately tilled and left fallow) or »Rottland« (if only occasionally cultivated). For the infield also the word »Esch« was used in contrast to »Kampen«, the outfield. Northern Frisian terms were »Täglich Land« for the infield and either »Wongenland« or »Heide« for outfield depending on its use for occasional cultivation or grazing, respectively. In France, the infield was called »mejou« and the outfield »tre« or »ker«; when the latter was turned into heathland or rough grazing, the name »lande« was used. Infield soils were termed »terres chaudes« (warm soils), outfield ones »terres froides« (cold soils). Mediterranean lands seem early to have been exploited by using the areas close to the farm for cultivation and the remoter ones for grazing, thus turning them into the well-known »maquis«. The previous Celtic area of France, Britanny, as well as the British Isles similarly saw the practice of infield-outfield farming (see e.g. C.T. Smith 1967). Also a distinct Celtic vocabulary is attached to this type of farming. On Keills (Isle of Jura, Scotland) e.g. the infield is »geadhail«, according to H. Uhlig, 1961. Functioning infield-outfield is still commonly seen in North Scotland and Ireland. A curious

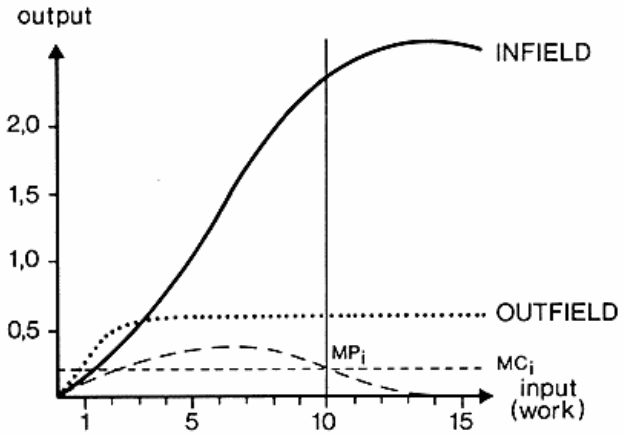

Fig. 1. Production per unit of area as a function of labour input. MP_i and MP_o are the marginal product-curves for infield and outfield, respectively. MC is the marginal cost, here used for finding optimum input-output combinations.
Fig. 1. Produktion pr. arealenhed som funktion af arbejdsindsats. MP_i og MP_o er marginalproduktkurver for henholdsvis ind- og udmark. MC er den marginale omkostning, her brugt til at markere den optimale input-output kombination.

field et vice versa. If the work applied to the nearest parts of the infield is w_o, daily working hours are h_d, and travelling time for a distance, a, is ht_a, the work applicable is expressed: $w_a = w_o - \frac{w_o}{h_d} \cdot 2h_{ta}$

The work reduction at a distance from the settlement naturally infers a decrease in yields. The available labour according to the formula above is illustrated by fig. 2. Corresponding reductions of yields inferred from fig. 1 can be seen from fig. 3. It is noted that the reduction in yields is not proportional with distance, but rather increases, except perhaps under very special conditions. E.S. Dunn (1954) and W. Found (1970 and 1971) arrived at a similar conclusion. If scattered plots are used, the increase in travelling and decrease in effective yields will be even greater (see S. Christiansen, 1977).

The stability of the infield-outfield system lies mainly in its ability to replace nutrient-ion losses. These are inflicted in two ways: by removal of harvest and by leaching. Most infield-outfield systems operate a very effective mechanism for the replacement of ion losses in the infield, namely an ion transfer from the outfield by means of livestock. Many authors do only consider the infield-outfield term appropriate for farming systems that include animal husbandry (e.g. D. Stamp, 1966, and P. Fénelon, 1970). Really effective ion transfer takes mainly place in systems, where ruminants — oxen, sheep and goats — are daily driven into infield stables or pens, from their outfield grazing, e.g. as it is necessary for the milking of animals. Droppings from the animals are then concentrated within the infield. Of course a similar effect can be produced, when fodder is transported from the outfield for stall-feeding of animals. The mechanism is illustrated by the following simplified calculation: one head of cattle in modern farming, when well fed, is estimated to produce 6 tons of dung and 3 tons of liquid manure during the period of stall-feeding pr annum, which is the equivalent of roughly 40 kgs of N, 80 kgs of P, and 100 kgs of K fertilizers on the basis of pure elements (Johs. Olesen 1963).

Losses of macro nutrient-elements per annum from 1 hectare with wheat

	N (kgs)	P (kgs)	K (kgs)
Losses by removal of grains per ton	22	4	4
Losses by leaching (Stålfelt 1960):			
Well-fertilized soils	67	0	100
Unfertilized	13.9	0	14.3
Fertilized, but without $CaCO_3$	13.7	0	13.8
Fertilized, with $CaCO_3$	15.8	0	12.9

Losses af macro nutrient-elements are seen from the table. From unfertilized soil a crop of less than 1 ton per hectare seems possible under North-European conditions. To stabilize such a production, weathering or fertilization must provide each hectare with at least about 35-40 kgs of N, 4 kgs of P, and 18-20 kgs of K. Any increase of production is conditioned by increased supplies of fertilizer. If the efficiency of manuring is put at 40% at a

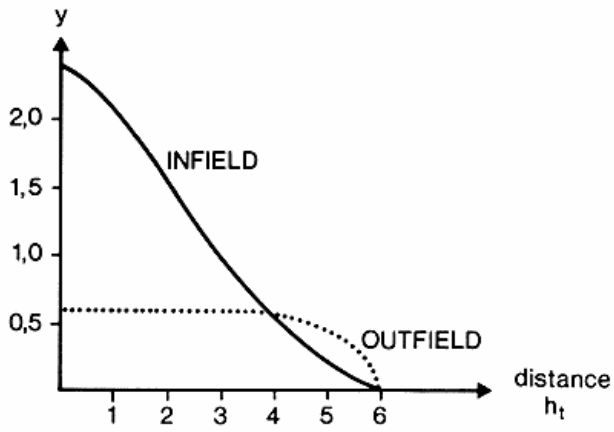

Fig. 3. Yields as a funciton of distance from farmstead. Only decrease caused by reduction in working hours from travelling home to field is considered. A further reduction, because of transport of produce, varies often in proportion with distance.

Fig. 3. Udbytter som funktion af afstand fra gård. Kun den reduktion, der skyldes formindskelsen i effektiv arbejdstid er medtaget. Yderligere reduktion fremkommer ved produkternes transport; denne regnes ofte proportional med afstanden.

minimum (concerning N), it is seen that an increase of yield amounting to about 1 ton per hectare, requires the manure from about 2½ heads of cattle to warrant stable production. The carrying capacity for population is thus doubled from about 4 to 8 people/hectare by the aid of just a couple of cows and a calf. Even if the estimate here proves too optimistic, manuring has considerable effects; habitual manuring usually kept the soil fertile enough to warrant an annual harvest instead of an occasional one. The beneficial effect was remembered by the saying »meadow makes/fattens the field« (eng føder/feder ager). As may be seen from the example above, nitrogen supply to the soil was comparatively scarce, especially considering heavier losses of nitrogen. No wonder then, that whereas sufficient phosphorous early was stored in the soil, the nitrogen problem remained to be solved by the introduction of legumes (white clover) and later — mineral fertilization.

Clearly, even a small increase in fertility is of great concern for the total economy of the infield-outfield system because it lends greater effect to the labour in the infield. Maybe one of the greatest advantages of the system, its main strategy, lies in its capacity of building up fertility and hence provide the basis for an increasing intensity. The importance of an increase of fertility of the soil is probably best illustrated by relating it to the yield/seed ratio, f. A simple equation connects net yield, Y_n, with gross yield: $Y_g : Y_n = Y_g \left(1 - \frac{1}{f}\right)$; Schlicher van Bath, 1971, cites a similar expression. From the equation follows, that an increase in f at low values means a high percentual increase in Y_n, the increase in net yields diminishes rapidly, when f is further increased, see fig. 4.

variety is found on the Outer Hebrides, where the outfield, »machair«, is of relatively greater importance than the infield — because of a more fertile soil. The Nordic countries use very similar terms for infield and outfield: inmark/indmark/bö for the infield, utmark/udmark/hauge for the outfield — plus a number of other terms for specific parts and features of both elements. Especially in the humid Atlantic areas of marginal cultivation of cereals, the infield-outfield system exists in several forms.

In other parts of the world many examples of farming systems are found to which the infield-outfield definition fits equally well. By the Zande-tribes of Sudan (Zaîre) the soil is cultivated in a »small rotation« and in a »large rotation« according to P. de Schlippe (1957). The system includes no domesticated animals, it is thus a kind of vegetable infield-outfield cultivation. The Bembas of Zambia cut large amounts of branches, concentrate them on their »infields«, burn them and cultivate in the ashes, (A. Richards, 1939), a system that possibly resembles neolithic systems to the effect of producing some kind of »leaf-meadow« (Swedish: »lövhage«) in vast areas around settlements. Tanzanians, e.g. the Buhayas, cultivate coffee, bananas and vegetables in the shambas (infields), greatly assisted by a build-up of fertility from the droppings of their cattle, see e.g. H. Ruthenberg, 1971. This is brought home for protection during nights after the day's grazing on the »rweya«-outfield. Probably the fertilizing is the most important benefit of the cattle: the soils are extremely meagre and hardly worth working on intensively without the added manure.

The infield-outfield systems — as previously defined — differ in some vital aspects. Each of their two elements may be used for either vegetable or animal production or, explicitly, may be used for either direct human vegetable consumption or for the sustenance of livestock. Except in some rare instances, only the following different products are realized: grass for grazing, grass for hay-making (winter fodder), and food crops (cereals). By definition, the infield must be at least as intensively utilized as the outfield. This leaves us with only the following combinations to consider.

	A	B	C	D	E
Infield	grazing	hay-making	cropping	cropping	cropping
Outfield	grazing	grazing	grazing	hay-making	cropping temporary

The combinations are arranged after increasing intensity. Type E has been widely practised on the European continent, where vast tracts of heathland were developed mainly as a result of shifting cultivation. Possibly, the D-type has been less important; the use of »dry meadows« (Swedish: fastmarksäng) and of degraded forests (Swedish: löväng) for leaf-fodder exemplifies this type. The archaelogical finds previously mentioned may support the idea of an old tradition for type D. Cropping-grazing

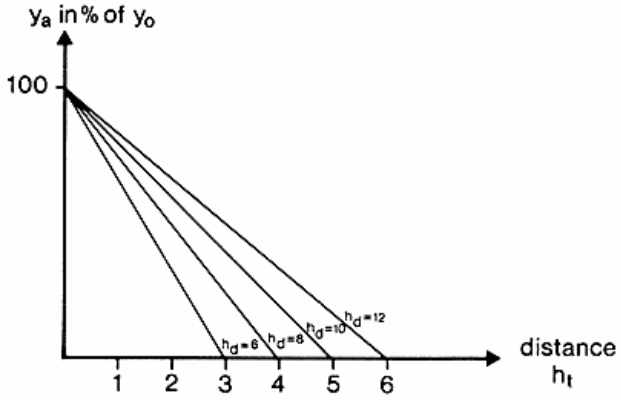

Fig. 2. Effective working hours, W_a, at a distance, a, from farmstead, expressed as a percentage of work at total capacity, W_o. Curves are shown for various lengths of working day, h_d.
Fig. 2. Det mulige, effektive arbejde, W_a, i afstanden a fra gården, udtrykt som procent af muligt effektivt arbejde, W_o. Kurver er vist for forskellig længde af arbejdsdagen, h_d.

combinations are probably the most common of all the types. Usually there is no sharp distinction between type C and D, as the C type often is established after an initial type E stage(s); the natural plant successions after shifting cultivaton usually provide good grazing, e.g. young heather is a fine fodder as well fresh as dried. Type B seems especially important in the North Atlantic area, where cereal production is severely hampered by the humid and rather cold summer. Introduction of potato-growing sometimes turned the B type into type C even in areas of this category.

If the infield-outfield term is applied only to farming systems with livestock, type E is not a type of infield-outfield proper. The reason to include it here is that the succession of types makes it difficult to draw a line of separation between the two. They occur simultaneously within the same farm on different pieces of land. From a geographical point of view it is important, further, that the cultural landscapes resulting from the two types are almost identical, at least in some stages.

Among the most important characteristics of the infield-outfield system is, that it is possible to establish it at very low capital inputs. The system is usually found within the sphere of pre-industrial agriculture.

Generally the effiency of farming systems can be described by the effect of its inputs on outputs, e.g. as depicted, by the production function fig. 1. The two elements of the system behave rather differently. Maximum gains are by far larger for the infield, but acquired at higher levels of work inputs. The outfield yields at very small inputs. However, its maximum yields are soon reached and the system difficult to change for further improvements. Returns of both infield and outfield are severely reduced by the effects of journeying from home to

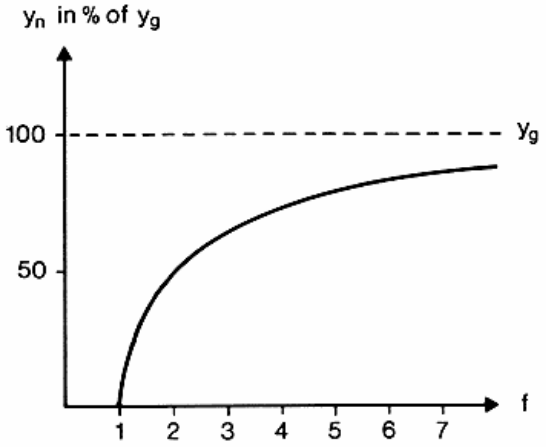

Fig. 4. Net yield, Y_n, expressed as percentage of gross yield, Y_g, in relation to yield/seed ratio, f.
Fig. 4. Nettoudbyttet, Y_n, udtrykt som procent af bruttoudbyttet, Y_g, som det varierer med voksende foldudbytte, f. (= høstudbytte/såsæd).

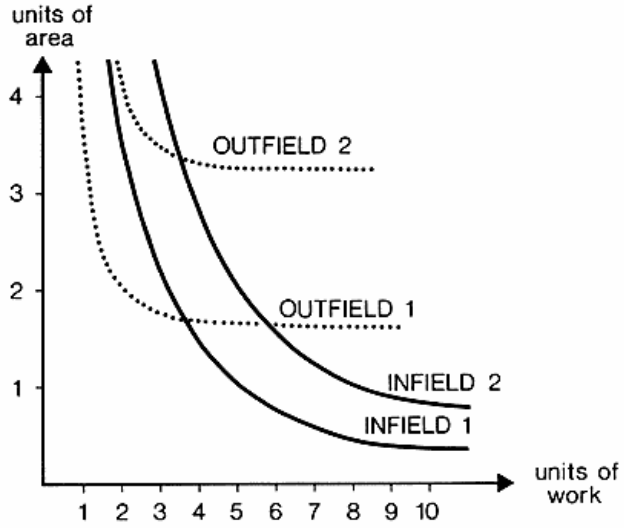

Fig. 5. Combinations of area and work inputs to produce 1 (2) units of output in infield and outfield respectively.
Fig. 5. Areal-arbejde kombinationer nødvendige for produktion af én eller to enheder af udbytte, vist for henholdsvis ind- og udmark.

During the Middle Ages, f values were normally rather low, usually about 3. Hence, use of the infield-outfield system was very advantageous. The beneficial effect on soil fertility was widely acknowledged as by the saying »meadow makes the field« (Danish: »eng er agers moder«). In fact, there were only two alternative methods for improvement of soil fertility: the use of fallow or of leguminous plants. Only the discovery of mineral fertilization brought a drastic change into this state of affairs.

Different combinations of area and work inputs resulting in equal yields are depicted in fig. 5, which is in principle derived from fig. 1. It is seen that the outfield production alone is advantageous, when labour is scarce and land not. This points at the explanation touched upon earlier, that use of outfield alone was possibly the origin of the system. But it is also evident that a need for higher carrying capacity, which implies greater yields per unit of area, makes a combined use of infield and outfield necessary. Population pressure may have been one of the driving forces behind this (E. Boserup, 1965). The normal development of the system makes the infield encroach upon the outfield.

Except for the minimal infield necessary to produce the fodder for the livestock during winter, it is not rewarding to cultivate the infield. At the stage of its first occupation, land will hence be utilized as outfield, such as after burning of forest and scrub, to turn the areas into accessible grazing. Remote outfields may be utilized from special cattle/sheep booths like in the »saeter« of Norway to cut journeying expenses. Under stable conditions, a delicate balance develops: experience teaches the farmer to regulate the amount of livestock, and to cultivate infield areas in relation to the need for winter fodder and thus indirectly to relate infield to outfield areas (as shown by J. Brandt, 1973).

If an increase in demand for products develops, and all areas are utilized, the infield must be exploited harder. Usually the next step in development will result in more areas under crops of cereals until a new balance is achieved. In many infield-outfield regions, some sort of stability seems to have been established for very long periods. To curb increases in population several regulations were inflicted on marriages etc. at least in some places. The introduction of the potato and other crops gave new means to increase carrying capacity of the infield-outfield system. Normally the development led to establishing of new settlements in the outfield which resulted in its final disappearing. In some regions, however, the infield-outfield system held its ground, and is still functioning. An example of this shall be briefly described, and the reason for its survival discussed below.

The infield in contemporary Faeroese farming is used for production of potatoes for direct human consumption, for growing grass for cattle grazing and for hay to sustain both cattle and the outfield sheep during winter. Some Faeroese farms, especially on Sandoy, emphasize milk production from infield cattle — a combination of the above sketched types A and B. Where sheep raising is more predominant (mainly on the northern island), a distinct type of B farming is found. Generally the C type operational scheme has lost importance by the competition from imported cereal, and other food.

Why has the infield-outfield system survived that well on the Faeroes? Firstly, the outfield areas are more difficult to use for cultivation than in most other places because they are largely found in the highland. They can hardly be used for cultivation of cereals unless at high risks because

of the climatic gradient. However, such risks have apparently been taken, as traces here and there indicate former (occasional?) cultivation. Secondly, as the outfield yields fairly well in proportion to labour inputs thanks to an effective system of herding, there are reasons to believe, that the infield is rather an appendix to outfield than the opposite. The purpose of the infield is then mainly to supply fodder enough for the survival of the sheep flocks during hard winters and to sustain the cattle throughout the year. In this way the high potential for grass-growing is exploited instead of the lower, much more unreliable potential for cereal growing. It is seen, that the demanding operation of the infield is an essential link in the system, a link that cannot easily be dispensated with. Essentially the same reasons can probably be given for the success of infield-outfield farming all over the North Atlantic farming region. The idea of infield-outfield farming has apparantly been realized from the times of the earliest occupation of the Atlantic islands. Hear the words of Egil's Saga of the landnamsman Skallagrim just landed on Iceland: »He was keen on exploiting all resources to produce food for people. In the beginning they had, however, in relation to the amount of people, only few heads of cattle. The cattle, they had got, had during winter to roam the forest and find the feed for themselves«. Skallagrim's worrying about the winter fodder is obvious as is the reference to the normal way of solving problems to keep livestock in winter. Fortunately, he found himself a good place where »he let cereals be sown and called it »Akra« (acres)«. The infield-outfield pattern was established, and a successful system underway, able to survive to the present day!

RESUME

Indmark-udmarkssystemer defineres som landbrug, der udnytter to arealklasser med distinkt forskel i intensitet: indmarken er oftest dyrket med korn med ingen eller kort brak, og udmarken dyrkes temporært eller anvendes til græsning. Sådanne systemer kendes fra hele Vesteuropa, men der findes også en del eksotiske eksempler.

Karakteristisk for i-u systemer er, at de kræver ingen eller lille kapital; de hører fortrinsvis hjemme i ikke-industrialiserede områder. Derudover er de karakteriseret ved deres *effektivitet*, som vist ved produktionskurver, se fig. 1. Indmarken giver først udbytter ved relativt stor arbejdsindsats, mens udmarken yder relativt godt ved lidt arbejde, men til gengæld hurtigt når sin højeste ydeevne.

Udnyttelsen belastes meget af tidstab ved arbejdsrejser; afstandsforøgelse reducerer udbyttet, så dette ikke falder proportionalt med afstanden, men falder endnu stærkere.

Stabiliteten for i-u systemer opretholdes på forskellig måde, oftest ved, at græssende dyr (drøvtyggere) fjerner plantemateriale fra udmarken og om natten afleverer dette plantenæringsindhold som gødning i indmarksområdet.

I-u systemernes strategi karakteriseres ved deres evne til at formidle overgang fra arbejdsekstensiv lavtydende, men alligevel meget lønsom, udnyttelse til arbejdsintensiv og højtydende funktion.

De fleste steder er i-u systemerne intensiveret bort, især efter at mineralgødning er kommet til rådighed. Enkelte steder, specielt i den fugtige nordatlantiske landbrugsregion (eller Færøerne) er systemet bevaret. Årsagen dertil drøftes. Der angives som hovedårsager, at indmarken er delvis klimatisk afgrænset i landskabet, og at regionen befinder sig i et usikkert grænseområde for kornavl. I græsklimaet er husdyrhold, støttet af indmarkens vinterfoderproduktion, både fordelagtigt arbejdsmæssigt og med hensyn til stabilitet.

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