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Food Security in North Korea: Designing Realistic Possibilities

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About the Author

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Prior to his work in North Korea, Dr. Ireson worked in numerous other development projects in Asia, including seven years in Laos spanning the period from 1967 through 1994. He established the Community Aid Abroad (Australian Oxfam) program in Laos in 1988. He has coordinated the formation of water users' groups in Pakistani and Lao irrigation projects, and assisted in program design and evaluation for several NGOs, bilateral and UN assistance agencies.

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The Context of Agricultural Collapse

Between about 1990 and 1996, North Korea experienced what can only be described as a catastrophic economic collapse, which included a 70 percent reduction in food production compared to the late 1980s. The Democratic People's Republic of Korea (DPRK) initially insisted that the agriculture collapse was a consequence of natural disasters. However, it is clear that the seeds of this catastrophe had been planted decades earlier, the result of ill-advised and ultimately unsustainable national agricultural policies. Yet difficult as the situation is, it is not without options for significant improvement. This paper outlines a strategy for agricultural revitalization in North Korea, which could, in the foreseeable future, enable the DPRK to produce—domestically and in a sustainable manner—nearly all the food needed to supply a basic balanced diet for its population. Whether this strategy can be implemented, or indeed whether it is the best strategy for the DPRK in the longer term, depends on many factors outside the farm sector, including world and regional international political issues, and DPRK policy choices regarding participation in world trade and commerce.

An international conference in mid-2005 explicitly considered some of the appropriate steps that would be needed to provide substantial international assistance (Stanley Foundation 2005). The September 2005 joint statement from the six party talks raised the hope that a resolution of the nuclear weapons issues might open the door to international development assistance for the DPRK. However, subsequent developments suggest that agreements leading to significant economic assistance are still elusive. The DPRK also announced in September 2005 that it would accept no further humanitarian aid from international donors, effective at the end of the year. Only development assistance would be accepted. This position implies an end to the food and medical assistance that has played a central role in stabilizing the DPRK economy over the last decade. Whether the DPRK government believes that its farm production has risen to a level that can truly feed the population, that food and fertilizer will be available from other channels (e.g., China and the Republic of Korea, or ROK), or that a renewed famine is preferable to accommodation of continued international aid monitors, remains to be seen. But regardless of their motivation, it appears that DPRK authorities believe that the domestic food supply can be significantly improved within a very short time. This paper outlines one strategy through which that outcome becomes realistic.

To understand the possibilities for revitalized North Korean agriculture, we must first understand the history leading to the present situation. Emerging from the Korean War, the DPRK built a successful industrial economy over at least 25 years that housed, fed, and cared for its people—and for about the first two decades, at a higher level than in South Korea. Supported by concessional trade with the USSR and China for fuel, fertilizer, and raw materials, in the 1980s the DPRK arguably produced enough food to feed its population. This achievement was predicated on land reform and cooperativized farming, and on the development and expansion of an industrial farming model supported in turn by domestic production of farm machines, irrigation pumps, and—to some extent—fertilizer. Four "rural technical revolutions" characterized the North Korean farming model: "chemicalization," mechanization, irrigation, and electrification (O 1986). Absent their ideological underpinnings, these are also the foundations of modern North American and European farm technology. Following this system, annual grain production in the DPRK reportedly rose to over 8 million tons by 1989.

But there is a critical difference between North Korean policy and the Western approach to farming. Under the DPRK command economy, and consistent with the *juche* ideal of self sufficiency, DPRK agricultural strategy emphasized grain production to provide people's basic caloric requirements, and further decreed that yields be raised to levels that would meet these nutritional requirements, without considering either the economic or environmental costs of this level of production. On my first visit to the DPRK in 1998, a study advisor at the Grand Peoples' Study House (the national library in Pyongyang) explained the differences in perspective between Marxism-Leninism and *juche* as follows: Marxism-Lenininism incorrectly believed that if appropriate socialist economic institutions were created, then the people would, through the influence of these institutions, adopt a proper socialist ideology and outlook. *Juche*, on the other hand, recognizes that ideology must be the primary force. When people are taught and believe the correct ideology, then a true socialist population will emerge and the appropriate economic and political structures can be developed.

A crucial element of *juche* was the ability to say to the world: "we are feeding our people by our own means." It was irrelevant, for example, that the cost of fertilizer needed to raise rice yields from seven to nine tons per hectare was greater than the cost of buying the same two tons of rice on the world market. And in any case, the DPRK did not pay world prices for fertilizer, fuel, or feedstock, because of its concessional trade relations with the USSR and China. Similar trading patterns characterized other sectors of the economy, and thus the "success" of *juche* was achieved through a hidden subsidy, which the DPRK did not acknowledge to even its fellow Communist donors. (Szalontai 2004; Schäfer 2004)

Dependent therefore on the import of farming supplies at below-market prices, DPRK agricultural productivity was unstable and vulnerable.[1] The dissolution of the USSR, and concurrent Chinese insistence that the DPRK pay for imports at market prices in convertible currencies created a crisis from which the country has still not recovered. Deprived especially of fertilizer, food production fell to about 30 percent of its 1990 level over six or seven years, with grave consequences for the North Korean people.

Because of the direct and immediate link between food consumption and human health, the agriculture crisis has been the most visible symptom of the DPRK's general economic collapse. But because of the distributed nature of agriculture, and the ability in some respects to substitute labor for capital and other inputs, it is also the sector most amenable to a rapid turnaround. With appropriate changes in farm strategy and methods, together with allocation of certain selected industrial and labor resources to agriculture, production could be substantially increased within a period of a few years. Achieving near-self-sufficient food production would give the government a breathing space in which to institute other policies and investments aimed at rehabilitating the industrial sector.

Agriculture policy in the DPRK is related to other issues of international concern. Food security is and has been an important element of overall DPRK security. The Workers' Party 2005 joint New Year Editorial lists agriculture as "the main front of socialist economic construction." (KCNA 2005) Nearly the same phrase was used in the 2006 New Year Editorial, with agriculture the first priority after military defense. (KCNA 2006) Food aid from the international community has provided humanitarian relief to selected vulnerable population groups. Because food is fungible, aid to any subgroup raises the overall nutritional level in the DPRK. But the DPRK government also knows that food aid is unreliable and, despite official assurances of its nonpolitical nature, that it is subject to the goodwill of and good relations with donors. In contrast, foreign aid—which encouraged and promoted sustainable food *production*—could not be used for weapons, but could still create a greater sense of security for the DPRK, possibly reduce the perceived external threat, and enable improved international cooperation in other areas. To be successful, foreign assistance designed to reorient and revitalize farm production would require a level of cooperation and exchange between DPRK scientists and technicians and their international counterparts well beyond anything that has been achieved in the last decade. Such exchange, in and of itself, would provide an important stimulus to greater openness and interaction between the DPRK and its neighbors.

The Structure of North Korean Agriculture

Prior to the partition of the Korean peninsula after World War II, the Japanese colonial government had developed the northern part of the peninsula as the industrial core, and used the south as the grainary. North of the 38th parallel, wheat and barley were grown more than rice, as these crops were better adapted to the colder climate and shorter growing season. Even today, about three-fifths of farmland in the ROK is rice paddy, while less than one-third in the north is paddy. (KREI 1999: 347) The entire peninsula is mountainous, and soils are old and weathered. The Food and Agriculture Organization of the United Nations (FAO) estimates DPRK arable land at about 2 million hectares, of which 1.4 million hectares are suited to cereal production. The remainder is sloping land planted to fruit orchards and industrial crops such as ginseng and tobacco.

Considering only the area suited for grain and other field crops, per capita arable land is only about 0.06 ha per person. The average frost-free period is also short, though in an effort to boost maximum production, DPRK rice and corn breeders emphasized the development of long-maturity varieties—typically over 150 days for both crops. In order to successfully grow such varieties, farmers have developed cultural adaptations, such as planting rice and corn seedbeds in March or April and covering them with clear plastic. The four- to five-week-old seedlings are transplanted beginning in mid-April for corn, and in early May for rice. While rice transplanting is a common practice throughout Asia, only the DPRK transplants corn on any significant scale. The practice does extend the growing season and conserves limited early spring soil moisture, but requires a very great labor investment, as well as regular replacement of hundreds of thousands of square meters of plastic sheeting used to cover the seedbeds.

Another strategy to maximize local production is the near-exclusive emphasis on grain production. Because rice is the preferred Korean staple food, the DPRK invested much effort to enable large-scale cultivation of rice in locations farther north than almost anywhere else in the world. Predictably, the water and energy requirements for rice cultivation in this setting are significant.

In paddy cultivation, rice can be grown year after year in a manageable system. But repeated cultivation of corn on rain-fed fields has several deleterious effects. Farming grain after grain drains soil nutrients, especially when mineral fertilizer is unavailable; soil structure is degraded, and disease and insect pressure builds. Until a few years ago, government policy strongly resisted rotation cropping with noncereal crops, especially legumes such as soybean. Since about 2004, farms have begun, on their own, to augment soybean production, but are quick to cite the requirement that they maintain a specified grain production level. This paper considers this trade-off in more detail below.

As noted earlier, DPRK agriculture relied on an active industrial sector to provide the resources needed for high farm yields. Rice fields were irrigated by means of an extensive system of pumps and reservoirs that maintained productivity but also consumed a substantial portion of the country's electricity generation capacity. Some international agriculture assistance workers have reported seeing extreme cases where rice paddies were located several hundred meters above the nearest water supply, with a series of staged pumps designed to lift water to the fields. No economic or energy calculus can possibly justify such farming methods.

Woon-Keun Kim (1999) cites elements of the 1971–84 planning documents that clearly illustrate the DPRK's intensive farming strategy:

- 100 percent irrigation of nonrice upland crops
- Target annual production of 10 million metric tons (MT) of grain
- Distribution of one tractor per 10 ha
- Application of 2 MT/ha mineral fertilizer

With respect to the last item, in the context of the rural technical revolutions, "chemicalization" meant extremely high applications of fertilizer, primarily ammonium sulphate produced by archaic technology. The UN consultants who evaluated possible rehabilitation of the Hamhung fertilizer plant reported that the plant was based on 1870s production methods! (Lemaire 1999) It is doubtful that the target application of 2 tons/ha (equivalent to 400 kg/ha of nitrogen) was ever achieved, but ammonium sulphate fertilizer has an acidifying effect on soil, and its intense application over two or more decades has effectively burned most organic matter from the soil, and increased soil acidity in some areas to levels that may inhibit crop production (pH of 5.0 to 5.5). Concomitant with the heavy application of mineral fertilizer, rice and corn varieties were developed to utilize, albeit inefficiently, these high rates of nitrogen. Thus, ever-higher yields were possible, but again these yields could not be justified by either economic or energy analysis.

Farm mechanization was accomplished principally by means of the Chollima tractor. One of my DPRK guides told me that shortly after the Korean War, China offered to sell the DPRK all the farm tractors they needed for the indefinite future.[2] The Korean response was, according to this account, "What if you change your mind later? Just sell us two." Those two tractors were reverse-engineered to become the Chollima tractor, which has been the backbone of DPRK farm mechanization for the last forty years. Innovative designs of rice transplanting machines facilitated this labor-intensive aspect of farming, but like the Chollima tractor, the transplanting machines have been neither replaced nor modernized since they were first introduced. They are now barely functional, even though they are completely overhauled each spring by ever more ingenious farm mechanics in a never-ending effort to keep them working for one more season.

Stationary rice threshing machines located at each farm work-team center also contributed significantly to farm mechanization. With threshing centralized, measurement of production and distribution of shares among the government, farm common fund, and farm households could be controlled. Centralized threshers also minimized the mechanical investment required at each farm, but required that farmers carry twice the weight of rice (because the straw weight equals the grain weight) from the fields to the threshers. Farmers also thereby removed the straw from the fields, rather than returning this important organic matter to the soil. Soil fertility was further reduced, and since the acute energy crisis of the 1990s, virtually all rice straw and corn stalks have either been burned as fuel (by families lacking coal or other fuel), fed to animals, or woven into bags to store and transport grain and other commodities. Like the Chollima tractor, the threshers are extremely energy-inefficient. Powered by a 28 kw electric motor, their output is only 500 to 700 kg per hour—about 70 percent of the production of simple mobile threshers produced in China and powered by an 18 kw diesel engine.

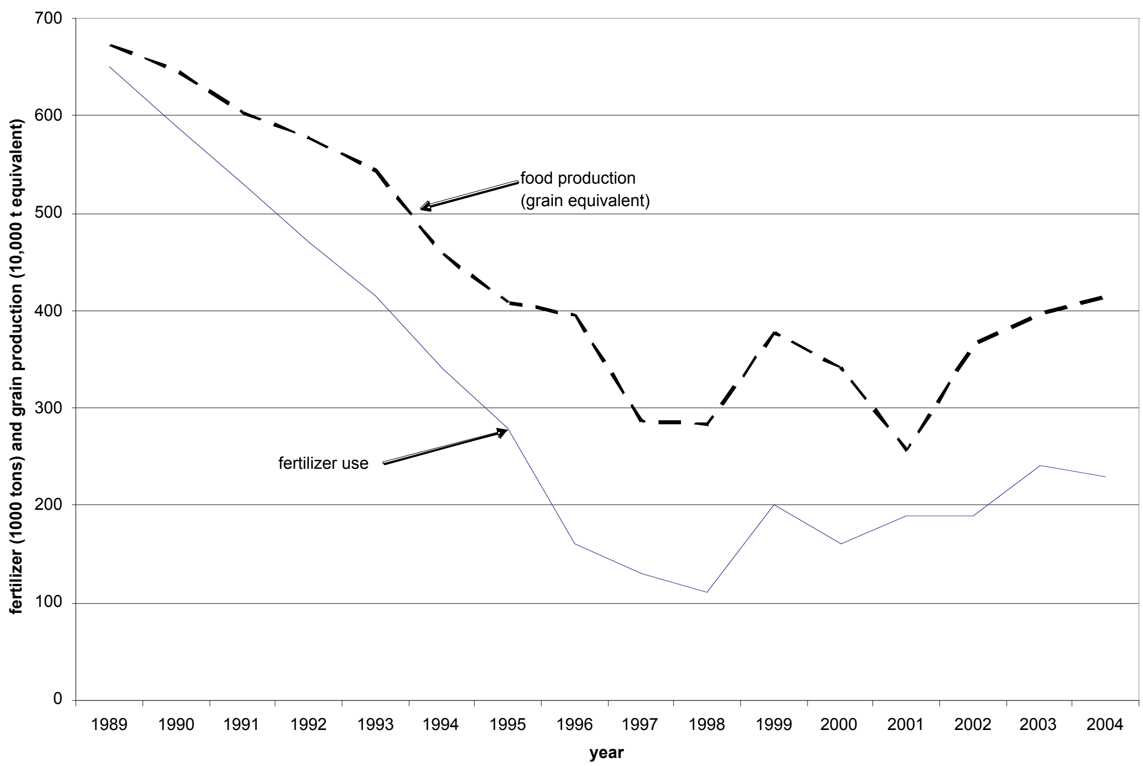
Possessing only coal and hydropower as domestic energy resources, the DPRK is completely dependent on imported liquid fuels (diesel and gasoline) and feedstocks (naptha and other petroleum products) for their agricultural chemical industry. Thus, finally, the DPRK agriculture crisis originates in an energy crisis. Having committed to an industrial farming model, but one guided by ideological considerations rather than by economic cost-benefit analysis, the farming system was almost completely dependent upon imported energy at subsidized prices. After the Soviet Union dissolved in 1989, and the Chinese at the same time demanded payment for fuel imports in convertible currency at world prices, the DPRK could no longer feed its industry, and therefore also could not support its agricultural production. Figure 1 shows that fertilizer use—which was highly dependent on direct imports or imports of raw materials—fell steadily from 1989, and grain production tracked the fall very closely.

Other aspects of the DPRK farming system compound the difficulties. Central planning and central diffusion of simplified farming rules strongly inhibited local adaptive behavior. Farmers in each region of the country have memorized specific dates by which rice and corn must be planted. Annual variations in weather are not taken into account, and the long-maturing grain varieties also enforce a certain rigidity in planting dates. For the first three years I worked in the DPRK, I was also told repeatedly both by farm managers and scientists at the national agriculture academy that one kilogram of fertilizer (meaning ammonium sulphate) applied to the field would produce an additional 10 kg of rice. This is simply not true, because the fertilizer response curve for all crops begins to flatten after a certain point. It was not until 2000 that anyone in the DPRK began to acknowledge the fact of declining marginal returns.

Traditional knowledge of adaptive farming methods was also lost during the indoctrination about modern farming. Our aid project was attempting to reintroduce green manure cover crops, which had been grown throughout Northeast Asia (including Korea) in the 1930s and 1940s. But in our conversations at farms and research institutes, we could find no one who recognized these crops or knew how they had been used. Finally at one farm, the research manager—a thoughtful gentleman in his sixties—said, on seeing a picture of Chinese milk vetch, "Ah! I remember my parents planting that in the fields in Chongjin. It has lovely purple flowers and we boys would weave garlands for the girls to put in their hair."

Finally, the normal yearly rainfall pattern in Korea is not optimal for crop performance. Spring is often very dry, and even in normal years the rain does not provide enough moisture for young plants. Sixty percent of the annual rainfall comes between mid-June and mid-September, often in torrential storms. Crop damage from heavy rains and/or flooding cannot be easily prevented. The rice irrigation system mostly insulates rice from early season moisture stress (assuming electricity for the pumps is supplied), but rain-fed crops such as corn, wheat, and soybean are frequently damaged by intermittent early rains, or, as in 2002, by lengthy drought.

Figure 1. Fertilizer Use (nutrient tons) and Food Production (grain equivalent tons)



Food Self-Sufficiency and Food Security

For the last eight years or so, both the domestic and international response to the DPRK economic collapse has been to buy time. Massive shipments of food aid have, at least through 2005, controlled the malnutrition-related mortality that claimed somewhere between 5 and 10 percent of the population in the mid-1990s. Food aid, however, has had no effect on the North Korean production system, whether industrial or agricultural. It is expensive, but because it does not contribute to any lasting security, it can be manipulated as a tool to further donor nations' political agendas.

Donations of fertilizer are more cost-effective than donations of food. A dollar's worth of urea translates into around five dollars worth of rice or corn. But while fertilizer donations increase farm production, they also enable the continued energy dependence and energy inefficiency of DPRK agriculture. Double-cropping strategies, promoted since 1999, are an effort to squeeze more juice from an already dry orange. Planting winter wheat or spring barley produces a small but important grain harvest in June, when food stocks nationwide are very low. But without fertilizer, yields cannot be sustained and soils are only further depleted. Grain-on-grain farming is difficult, but when two grain crops a year are expected, the system will surely collapse.

Ultimately, working harder and with more enthusiasm, even assuming increased efficiency, will not resolve the North Korean food problem. A new strategy is needed, one which fully recognizes and works within the current ecological and economic constraints, and which at the same time provides a means for eventually moving beyond those considerable limitations.

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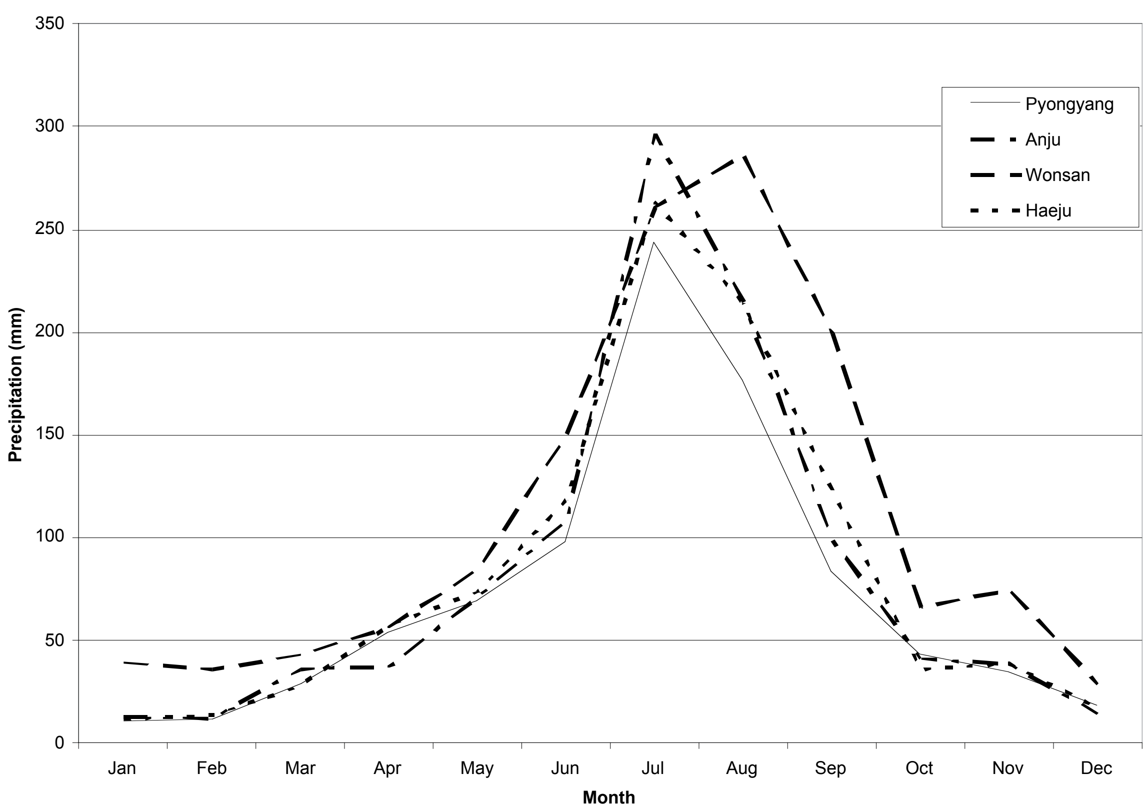
Figure 2. Average Monthly Precipitation for Selected DPRK Locations



Over the last several years, the DPRK has begun to emphasize development of "organic farming" both because of the shortage of mineral fertilizer, and the long-term deleterious effects of high fertilizer applications. Most North Koreans with whom I have discussed this policy understand "organic farming"—or *yugi nongpop*—differently from what we in the West consider it to be. To North Koreans, organic farming is closer to what the ROK and China sometimes call "green farming." *Yugi nongpop* in the DPRK does not necessarily imply 100 percent certified organic production, but rather an increased systematic use of biological nitrogen sources, and a reduction in chemical pesticide use. A contributing element is the effort to breed new rice and corn varieties that make more *efficient* use of soil nutrients (rather than exhibiting maximum possible response to high fertilizer rates), mature more quickly, and are more resistant to pests and diseases. As currently disseminated to farms, the organic farming policy emphasizes unrealistic goals for compost production (20 tons/hectare, when there are few organic wastes available anywhere in the farming system), and use of "Effective Microorganism Fertilizer," a bacterial product (Higa 1996) that facilitates compost decomposition and soil nutrient release. Though a step in the right direction, this effort is still incomplete. Scientists in several DPRK agricultural research institutes are trying to develop more systematic and operationally feasible approaches.

Under its *juche* ideology, the DPRK has emphasized self-sufficient food production, a goal that it accomplished for a short time only by means of substantial subsidized imports of energy and crop nutrients. Certainly many other countries (including the United States) also import the energy and materials needed to produce adequate food, but those imports are paid and accounted for at market prices (even granting certain market distortions).[3] Given the substantial environmental constraints on agriculture in the DPRK, we can legitimately ask whether food self-sufficiency should in fact be a policy goal for North Korea. Should the government reach for self-sufficient production, or for food security instead? The ROK, with twice the population and about the same amount of farming land, is certainly food secure, but imports over 70 percent of its grains, primarily corn and soybean for animal feed. (KREI 1999: 111f, 347) These imports are paid for by earnings from dynamic industrial and service sectors.

Food security means a population has the ability to reliably produce *or* purchase food year after year, and that saved reserves (whether of food or other resources) are adequate to compensate for occasional low harvests or years of low industrial production. The diet is diversified, farming practices are sustainable, and farming "at the margin" is unnecessary. Some farm products may be exported to buy other foods. Noland and others have argued that the only solution for the DPRK economy is a trade- and reform-centered policy that relies on the sale of services and industrial products to finance imports of needed foodstuffs. (Noland 2001) The recent Berlin conference on future assistance to the DPRK also accepts this conclusion. (Stanley Foundation 2005) While economically reasonable, this analysis assumes that both the substantial investment funds and the time necessary to transform the DPRK into another Asian Tiger will be available. It also ignores strong autarkic tendencies in DPRK policies. In ten or twenty years, Noland may well be correct, but a much more relevant question for the present moment is how the DPRK can achieve food security in the near future.

One could cynically argue that so long as the DPRK possesses a credible nuclear threat it can maintain food security through the use of blackmail for continued food aid. The September 2005 rejection of continued food aid suggests, however, that the government may have decided against this strategy for the moment. While an effective short-term method for securing external resources (and thus for fulfilling the energy-importing condition needed to forestall entropy), such a strategy is no more sustainable than the DPRK's previous reliance on subsidized fuel and fertilizer, or than continued donations of fertilizer. Prior to the early summer 2005—and therefore last-minute—ROK fertilizer donation, the UN Office for the Coordination of Humanitarian Affairs (OCHA) had forecast a substantial shortfall in fertilizer availability for 2005. (OCHA 2005)

A more reasonable approach to food security does exist. A careful analysis of the DPRK farming system suggests that self-sufficient food production is attainable, through the use of relatively sustainable farming methods. Furthermore, this goal could be achieved in a reasonable period of time, and would cost no more than continued food aid from the international community. Working toward the goal of short-term food self-sufficiency could be a politically acceptable avenue for international development assistance. If the DPRK becomes a more active participant in the world economy, it may eventually decide that self-sufficient food production is a suboptimal strategy and move instead to a more diverse farming system, relying on food imports to cover some portion of domestic needs. In that case, first implementing self-sufficient sustainable food production facilitates a safe path to eventual economic diversification. The choice of time horizon is crucial. Given the parlous state of all North Korean productive equipment, the goal for the next five years should be the achievement of a minimum state of food self-sufficiency. Surplus extracted from the agriculture sector, together with international investment or aid, could then provide the resources needed to rebuild the industrial and service sectors over a longer period.

Estimating Food Needs

The annual FAO/World Food Program crop assessment reports for the DPRK provide a first estimate of minimum production need. Based on a number of assumptions regarding population size, annual need for seeds, crop losses, and industrial uses of grains, the 2004 report estimates a minimum consumption requirement of 5.1 million MT grain equivalent[4] *including an allowance for post harvest crop losses*. (FAO 2004) All statistics related to the DPRK must be approached with extreme caution, but this estimate is a reasonable target for a minimum nutrition level based on a primarily vegetable and cereals diet. However, several of the assumptions on which this report is based merit further examination.

The FAO accepts the DPRK government's population estimate of 23.7 million persons. This estimate is based on assumed annual growth rates of 1 percent or slightly less since the 2001 baseline. However, that original baseline is unvalidated. Given the effect of severe food shortages on women's fertility, and the excess death estimates of between 600,000 and 2 million persons during the worst years of the mid-1990s, I suggest this estimate may be high by one million persons or more. There are no good data to support either position, and so for the sake of this paper I accept the FAO figure.

The FAO assumes a daily food grain requirement of about 460 grams (gm), which provides 1,600 calories, and assumes that the remainder of the calorie requirement will be met from other sources (vegetables, animals, fish, etc.). As a national average including children and elderly, this level is reasonable, but only assuming those other food sources are available. At present this assumption should be questioned; in a more productive and balanced farming system, it may eventually be met.

Estimated seed requirements closely track seeding rates reported to me by farm managers. The FAO also uses an estimate of 15 percent for post-harvest losses. This number is admittedly a very general guess, based on many factors but little or no direct data. The Korea Rural Economic Institute (KREI) estimates a 10 percent loss. (Choi & Phillips 2005) My own observations also suggest a very high level of post-harvest loss for the same reasons listed in the crop assessment report: delayed transport and threshing of grain causes rain, bird, and rat damage, and poor storage leads to quality deterioration and further rat damage.

Table 1 summarizes the FAO calculations. The FAO figure adds a 15 percent post-harvest loss to this total requirement. I point this out because it artificially inflates the consumption requirement. Curbing losses (almost always easier than increasing production) would go a long way toward meeting the annual human food needs.

Table 1. Minimum Grain Requirement for the DPRK

Direct food requirement: 23.7 million persons x 167 kg/person-year	3,979,000 tons
Seed for 1.42 million ha	229,000 tons
Animal feed (Ministry of Agriculture report)	181,000 tons
Other uses (3 percent of 2004 harvest)	124,000 tons
Total	**4,513,000 tons**

The FAO reports omit any quantified discussion of diet quality, especially regarding protein requirements and consumption. Ample anecdotal evidence, as well as the recent UNICEF-sponsored household child nutrition survey (Central Bureau of Statistics 2005: 8), indicates that ordinary DPRK diets have been chronically deficient in protein for many years. If we accept an average minimum crude protein requirement of 50 gm/day for the DPRK population, a population of 23.7 million would require about 433,000 tons of protein per year. Cereal grains and potatoes are, of course, not good protein sources. The Crop Assessment Reports do not estimate soybean production or consumption of animal protein (fish, livestock, or eggs). For at least the last ten years, soybeans have been grown mostly on field margins and paddy dikes, rather than cultivated as a primary crop. Planted area is therefore limited, and yields have been extremely low under these conditions, on the order of 1 to 1.5 t/ha.

The current production situation is summarized in Table 2. These figures are based on the 2004 FAO crop report, and have increased a few percent over each of the last three years. The DPRK government rejected an FAO crop assessment mission in 2005. No comparable estimates are therefore available for the most recent year, but most observers estimate a 2 to 4 percent increase over 2004 production. Cropped areas are basically stable, however, with yield variations reflecting rainfall, temperature, and farms' access to fertilizer. Analyzed in this way, we see that the net production of 3.51 million tons grain equivalent meets about 78 percent of the minimum national food requirement. Only about 55 percent of the protein need is met, and even that is unbalanced in terms of amino acid composition.

South Korean researchers make similar estimates of recent production and area planted. The Rural Development Administration estimate for 2004 food production is 4.3 million metric tons, or MMT (grain equivalent), compared with 5.1 MMT minimum demand. (Choi & Phillips 2005)

In contrast to the current situation, if the DPRK achieved reasonable increases in grain production, substantially expanded soybean area and yield, and controlled post-harvest losses, it could become self-sufficient in food production. Table 3 shows the calculations.

This model envisions increases in rice and corn yields by about one-third, the production of soybean on fully half the land now planted to corn (in a two-year crop rotation system), the reduction of post-harvest losses to 5 percent of the crop, the elimination of spring potato production and reduction of double-cropping area by one-half. The latter two changes remove low-yielding and stressful farming practices from the cropping system. Overall, this strategy, if it can be accomplished, would produce enough grain (including soybean) to meet 98 percent of the basic need, and enough protein (with a good amino acid balance provided by the soybeans) to meet 102 percent of the minimum requirement.

Table 2. DPRK Grain Production in 2004–05

Crop	Area (1,000 ha)	Average yield (t/ha)	Gross production (1,000 grain equiv tons)	Production less losses (1,000 grain equiv tons)	Seed needed (1,000 tons)	Net production (1,000 tons)	Net protein production (1,000 tons)
Rice	583	4.06	1540	1309	57	1252	81
Corn	495	3.49	1728	1468	22	1446	116
Other cereals	60	1.99	119	101	12	89	6
Summer potato	89	11.6	258	219	57	164	11
Spring potato	100	10.3	258	219	63	156	11
Double cropping	102	2.25	227	193	20	173	12
Total	**1429**		**4129**	**3510**	**229**	**3280**	**238**

Table 3. Possible DPRK Grain Production Model

Crop	Area (1,000 ha)	Average yield (t/ha)	Gross production (1,000 grain equiv tons)	Production less losses (1,000 grain equiv tons)	Seed needed (1,000 tons)	Net production (1,000 tons)	Net protein production (1,000 tons)
Rice	583	6.0	2275	2161	57	2105	137
Corn	248	5.0	1238	1176	11	1165	93
Other cereals	60	3.0	180	171	12	159	11
Main season potato	89	11.6	258	245	56	190	13
Double cropping	50	3.0	150	143	10	133	9
Soybean	248	2.2	545	517	15	502	176
Total	**1277**		**4645**	**4413**	**160**	**4253**	**439**

Restructuring DPRK Agriculture

The changes in farming productivity and strategy assumed in Table 3 are not insignificant, but they are reasonable targets. If accomplished, they can provide a path to short-term, self-sufficient food production, and an eventual transition to a national economy that does not rely fundamentally on agriculture. The national average rice yield in the ROK has been stable since the mid-1980s, ranging between 6.35 and 7.4 t/ha. Japanese yields have been slightly higher. Over the same period, corn yields in the ROK have varied between 4.1 and 5.1 t/ha. Soybean production has averaged around 1.5 to 1.8 t/ha, primarily food-grade soybean. (KREI 1999: 43)

By way of comparison, California rice farmers commonly achieve yields of 10 t/ha using conventional farming methods. One major producer—using no chemical fertilizer—averages 6 T/ha over a three-year rotation cycle. (Lundberg Farms 1998) Northern Iowa farmers report corn yields between 8 and 12 t/ha, and soybean yields regularly over 2.6 t/ha. Soybean yields between 3.2 and 3.6 t/ha are common. (cf. Iowa State University 2001)

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The yield targets assumed in the food sufficiency model are therefore achievable. The important question is how they can be achieved in the DPRK, using available resources and sustainable farming methods. The KREI has proposed one path to improved DPRK farm production. By relying on conventional inputs of fertilizer, mechanization, and irrigation, current ROK farming methods and seed varieties, combined with decentralized and individual management, the KREI estimates that total DPRK grain production could reach 6.0 MMT. (Kwon 2005; Kwon et al. 2005; Choi & Phillips 2005) This approach, however, makes the DPRK as reliant as it was in the past on imported energy and crop nutrients.

Farm production is limited in the DPRK by at least three major factors: lack of nutrients for the crops, water stress, and excessive post-harvest losses. Any successful development program must address each of these factors. Adopting several specific changes in DPRK farming practices, along with a few mechanical innovations, would have a substantial effect on farm productivity. These changes are listed in Table 4, together with their expected benefits. The reasoning behind each innovation, and an estimate of the production increase possible are discussed below. Other changes could also be proposed, but this list illustrates how a few relatively easy changes have the potential to greatly improve North Korean food security in a short time.

Crop Nutrition

Along with several other organizations engaged in agricultural assistance in the DPRK,[5] the American Friends Service Committee (AFSC) has been experimenting with the use of nitrogen-fixing green manure crops, which can be grown over the winter and early spring. Field trials at the four AFSC-assisted cooperative farms, as well as more closely controlled experiments at the DPRK Academy of Agricultural Sciences (AAS) and the Organic Agriculture Development Association (OADA) indicate that under appropriate conditions, hairy vetch grown in rice paddies and rain-fed fields is a crop which can withstand the DPRK winter, and produce significant biomass and nitrogen for the main season crop. Preliminary data suggest that a cover crop at the level of 10 t/ha fresh (green) weight can be plowed into the soil and provides the equivalent of about 60 kg/ha elemental nitrogen. This level of fertilization typically increases rice yields by about 1 t/ha in the first year. Because the nitrogen from the cover crop is gradually released by decomposition over several years, if vetch is continually planted each fall, the residual effect continues to increase production for three to four more years. In 2004, rice yields in green manure test plots at the AAS averaged 6.6 t/ha for ten varieties when fertilized only with 10 t/ha of green manure. Addition of 30 kg/ha mineral nitrogen raised the average yield to 7.2 t/ha. These test fields have now had hairy vetch or other green manures grown and incorporated for four years. Soil organic matter has increased from 1.9 percent to 2.5 percent in that time, and rice plants are visibly healthier and stronger. The response of corn to winter green manure production has not yet been systematically documented, but anecdotal farm reports indicate similar yield increases.

Table 4. Recommended Changes to Restructure DPRK Agriculture

Proposed Change	Effects
Plant winter green manure crops on rice and rain-fed fields	Increases yields without chemical fertilizer; improves soil health
Introduce rotary disk plows	Needed to plow green manure quickly in the spring
Produce green manure seed at local farms	Needed to maintain biological fertilization system
Practice crop rotation of corn or wheat with legumes	Increases yield; reduces disease; produces more vegetable protein
Install supplemental spring irrigation for 50 percent of rain-fed crops	Increases yield and reduces yield variation from drought
Supply mobile rice threshing machines	5–10 percent of crop saved by reducing post-harvest losses
Supply seed drills for wheat, corn, soybean	20 percent yield increase; labor-saving; more double-cropping possible
Purchase trucks to move crops and supplies	Tractors available for field work; increased fuel and labor efficiency
Limit potato farming to most appropriate areas	Less effort and fewer materials for seed production, crop care on smaller area; better yields
Plant sloping lands to permanent crops, including fodder	Stops erosion; makes feed available for livestock

A second aspect of soil fertility management is to rotate grain with legume crops. An obvious choice for the DPRK is to rotate corn with soy. One ROK assistance project is already successfully intercropping soybean with corn. (Kim Soon-Kwon et al. 2004) U.S. agronomists usually assume at least a 10 percent increase in the yield of corn following soybean, all other factors being equal, and a similar increase in the yield of soybeans grown following corn. Soybean can fix atmospheric nitrogen (N), and while much of that N is harvested in the soybeans, some additional store remains for the following corn crop. Crop rotation also interrupts disease and pest cycles, as the most common bean pests and diseases do not attack corn, and vice versa. Another interesting rotation now being tested at some DPRK farms is a winter wheat-late summer soybean double crop, followed by corn in the second year. While such intense cultivation is not sustainable without added nutrients, it is definitely less stressful than the more common wheat-corn double-cropping, and provides important protein to the diet.

Phosphate (P) and potash (K) are soil nutrients that are also needed for good crop yields. There are no simple biological sources for these nutrients, but the DPRK has locations at which both nutrients can be mined. Other cultivation practices can help augment P and K, such as returning crop residue (rice straw and corn stalks) to the soil. These residues, together with biomass from green manure crops, increase the soil's organic content, and thereby provide a more healthy environment for important soil microorganisms that help to decompose and release bound P and K reserves that are already in the soil.

Before use of green manure crops in the DPRK can be widespread, several obstacles must be overcome. First, suitable winter legumes have, to date, been identified for cultivation only in areas where winter minimum temperatures do not fall below about -26°C. This corresponds to areas south of about 39°30' in the coastal regions, but does encompass the majority of rice production areas. Clay soils or low-lying fields are also challenging to winter hairy vetch. Therefore further testing and evaluation of other green manure varieties is needed.

The second main concern is how to incorporate a one-meter tall, tangled mass of vetch into the soil of a corn field or rice paddy. Since the green manure crop should grow as long as possible in order to maximize biomass and nitrogen production, incorporation should ideally be delayed until late May, and accomplished within a two- or three-week period at each farm. The shortage of draft power at the farms therefore becomes a critical constraint. Furthermore, the common mouldboard plow used in the DPRK gets tangled in the vetch strands; rotary tillers are similarly ineffective. A simple, tractor-driven rotary disk plow produced in China has been tested and found to work very well with the standard 28hp North Korean Chollima tractor. Pulled by a Chollima, it is capable of incorporating a cover crop at about 3 ha/day. Absent substantial human labor to cut vetch by hand, this rate would imply the need for one disk plow for every 50–60 ha planted to winter green manure.

The final issue is local production of green manure seed. Vetch is planted at between 20 and 40 kg/ha as a green manure crop. To sustain this method of fertilization requires either that each farm produces its own seed annually, or that county or province seed farms engage in large-scale production of vetch and other green manure seeds. The institutional and logistical obstacles to the latter approach are daunting, especially given that farms currently do not even receive hybrid corn seed on a regular basis. Assuming current seed production yields of about 900 kg/ha (greater yields should be possible with experience) and average seeding rates of 30 kg/ha, about 3–4 percent of the total area planted with vetch must be given to seed production. Seed would be grown on rain-fed fields, not rice paddies, and the fields could be planted to a short-season food crop (vegetables or perhaps short-maturity soybeans) after the vetch seed harvest in July. Seed cleaning can be accomplished at each farm by means of inexpensive machines.

Water Management

As noted earlier, normal rainfall in the DPRK is highly concentrated between mid-June and mid-September. Crops with long maturity typical of most DPRK varieties must be planted beginning in April or early May. Soils are dry at this time, and rainfall is very intermittent and typically inadequate for optimal crop growth until at least mid-May, and often later. Droughts have occurred three times within the last eight years. In 2001, no meaningful rain fell anywhere in the country for 100 days, between March 4 and June 12.

Under such circumstances, supplemental irrigation during the early growing season can significantly improve yields. In drought years, irrigation makes the difference between having a crop and not harvesting anything. The extensive national system for rice irrigation relies on reservoirs, and is designed to provide adequate water during the growing season. The main period for rice irrigation occurs during soil preparation, transplanting, and early growth. The DPRK rice irrigation infrastructure is generally effective, though inefficient, and most pumps and pipes are old and need repair. Two recently constructed large diversion canals will greatly improve system efficiency and water storage.

Rain-fed fields—such as those planted to corn, wheat, potato, and vegetables—are mostly not irrigated, however, and yields vary greatly depending on rainfall and other factors. Groundwater resources in the DPRK (shallow and deep wells) have not been significantly developed. Only a little additional water would be needed to overcome water stress during the spring, as plants are still small, and temperatures are moderate. While crop evapo-transpiration may exceed 10 mm/day during the summer peak growth period, in the spring plants require less than half that much water. Simple movable sprinkler systems, supplied by either mobile pumps or fixed pumps with buried distribution lines, can easily and economically provide this amount of water. Limited experience with small portable diesel pumps and 100-meter-long sprinkler lines suggests that the increased corn yield gained by adequate spring irrigation will completely repay the cost of the pumps and sprinkler lines, as well as the operating expenses, in just one dry year. These irrigation systems would be designed to supply only enough water for the early season, through the end of May. Pump systems with greater capacity would be much less economical, and only seldom used to their full capacity.

Again, certain practical constraints must be considered. Some fields may not be located within an acceptable distance from easily developed groundwater sources (too high above a stream, or the subsurface water table is too deep for economical wells or pumping). DPRK farmers have some prior experience with sprinkler irrigation, especially for intensive vegetable production, but need training in effective operation of more modern pumps, sprinkler rotation patterns for efficient irrigation, and a more accurate understanding of crop water requirements. Finally, absolute shortages of electric power or diesel fuel (not just their expense) may limit the ability to develop this type of irrigation. However investment in simple pumped irrigation systems for rain-fed field crops would substantially improve yield stability, and noticeably boost yields every year.

Labor and Mechanization Bottlenecks

Three tasks in the DPRK farming system are currently not accomplished well, leading either to excessive crop loss after harvest, or a sacrifice of crop yield potential during planting. Post-harvest losses were discussed above, and are certainly at least 5 percent, if not much more. For rice, simple mobile threshing machines can speed the processing of the crop, and facilitate its removal from the field to secure storage. By threshing at the field, only half the weight and less than one-quarter of the bulk needs to be moved quickly from the fields. Rice straw, if it is to be used for feed, fuel, or other purposes, can be hauled later, after the grain has been stored. Simple 18hp diesel threshing machines can be purchased for about $2,100, and can thresh about one ton of grain per hour. Thus a single machine can thresh the production of about 2 ha/day, and one machine for every 60 ha could accomplish the harvest processing within a month. I estimate that such threshers would save about 5 percent of the rice harvest, based on reduced losses from more rapid processing. Fuel saved by not hauling rice straw from the fields could be used for the threshers.

Small grains, such as wheat and barley, are typically planted in the DPRK by broadcasting the seed at a high rate (200 kg/ha) in strips about 40cm wide, separated by about 20cm of unseeded ground. This facilitates weed control in the strips, but also leads to competition among the plants for sunlight and root development. Rather than broadcasting by hand, planting by grain drills pulled behind a tractor places seed at a precise depth and at regular spacing, giving each plant ample room to develop. Planting is also much quicker (3 ha/day with a 4.5 meter wide drill), and uses 10 to 25 percent less seed. Farms that have experimented with these machines report that wheat yield is increased by about 0.5 t/ha (more than 20 percent) because of better plant vigor. Soil preparation needs to be somewhat better prior to using a drill (although introducing no-till drills would remove this constraint). Faster planting of winter crops could also facilitate a modest expansion of double-cropping, although this is not a beneficial plan in the longer run. Double-cropping is currently limited by inadequate labor and machinery for fall planting, as well as by insufficient fertilizer for proper crop development.

The same seed drills can also be used for soybean and corn, and their implementation would result in similar yield increases over traditional methods. Once faster-maturing corn varieties are in common use, grain drills could enable direct seeding of corn in early to late May, freeing up substantial labor resources from the tedious corn transplanting task. The main obstacle to use of seed drills would be availability of diesel fuel.

Presently, farms use tractors pulling small trailers for virtually all movement of fuel, fertilizer, grain, and other supplies. This is extremely time- and fuel-inefficient, and diverts tractors from productive field work. Cargo trucks in the 5- to 8-ton capacity range will accomplish these tasks at least ten times more rapidly and with one-eighth the fuel consumption of Chollima tractors. All farms should be provided with trucks necessary to accomplish primary farm tasks. Fuel used by the trucks will be more than recovered by increased economy compared with haulage by tractors.

Other Modifications—Crop Mix, Infrastructure Support

Current DPRK agriculture policy strongly emphasizes production of grain over all other commodities. This is not wholly unreasonable given the economic and climatic constraints, but greater crop diversification would be advantageous in several ways. First, substantial expansion of legume crops (especially soybean, but also lentils, mung bean, and dry peas) would not only add much-needed protein to the diet, but also contribute nitrogen to the fields. Crop rotation of *all* rain-fed grain fields is absolutely essential for the long-term stability of DPRK agriculture.

The 2000 potato initiative, which has resulted in expanded potato production in certain areas where corn is a difficult crop, may be beneficial if significant management issues can be resolved. Promoted as a way to produce forty tons of food per hectare (but ignoring the fact that potatoes are 75 percent water), the initiative was an example of the over-enthusiastic and indiscriminate application of a good technique in inappropriate settings. Potatoes grow better than grain in colder areas and at higher elevations. But they require adequate time to mature, and premature harvesting substantially reduces yields. Potatoes require much more seed (2 t/ha) than grains, the seed is highly perishable, and it must be produced in carefully controlled settings to avoid propagating diseases to the crop. Good yields also depend on heavy fertilization (especially with potassium). Model farms in the far north that received inputs and technical support have reported yields over 40 t/ha, but this is clearly an exception. The national average is still around twelve tons, the nutritional equivalent of a 3 t/ha corn crop. Farms that have learned (mostly the hard way) that potatoes do not grow well in their location, have now abandoned the crop or sharply reduced the area planted. Others are gradually receiving the technical support, together with better quality seed and storage facilities.

Sloping lands that were cleared and farmed during the food crisis should be planted either to permanent tree cover or to fodder crops. A permanent vegetative cover on these steep hillsides will reduce erosion and increase absorption of summer rains into the water table. Fodder crops especially would support increased production of small ruminants such as goats, with direct benefits including milk and meat, and animal manure for household gardens. The production model outlined above, however, assumes that most dietary protein will be supplied by vegetable sources. Substantially increased animal and fish production is not assumed, and grain production requirement models do not budget for it. Any increased livestock production would thus be incidental and supplemental to the cropping budget outlined earlier.

The equipment needed to implement some of the changes discussed here—irrigation pumps, threshers, and seed drills—will require maintenance, repair, and training in proper use. Farm machinery work teams are skilled in keeping old North Korean equipment running, but the more modern equipment envisioned, while still simple in concept, will require a different approach. Spare parts will also be needed. In the longer term, it would be beneficial for the DPRK to produce this new farm machinery itself, though initially machinery may have to be imported from China. Spare parts can be similarly imported, assuming the DPRK government allows foreign exchange to be used for this purpose. Following the June 2003 economic reforms, trading networks have already developed to provide some Chinese and Japanese repair parts to DPRK consumers, but the networks are convoluted, and prices are much higher than appropriate. Some investment in upgraded farm-level repair workshops would also be desirable.

Finally, researchers at the AAS are in the process of developing new rice and corn varieties that mature faster and more effectively utilize lower levels of fertilization than the old varieties. This process can only be accomplished over time, but it is moving in the right direction. Eventual provision of new varieties and high quality seed to the farms will contribute to rising production.

The Cost-Benefit Question

The changes recommended above for the DPRK agriculture system will require substantial investment, as well as several changes in national farm policy priorities. We can develop estimates for the cost of implementing each of the changes discussed, costs that include seed, equipment, and extension activities. We can then compare these costs with the current costs of providing food aid to the DPRK, which are relatively well known. The cost of investing to restructure the DPRK agriculture system is of the same magnitude as that of providing food assistance, and has the advantage of providing a clear path to food security for the DPRK.

Costs of Food Aid

The World Food Programme (WFP) delivered food aid to the DPRK from 1996 through 2005. Annual quantities ranged from a few hundred thousand tons to over one million tons in 2002. China and the ROK continue to provide food aid through bilateral channels. The annual DPRK food production deficit has sometimes exceeded two million tons, and since 1995, has never been less than 900 thousand tons. The FAO assumes that one portion of this deficit is covered by commercial purchases and one portion by unpublicized aid from China. The ROK has also made highly concessional rice loans in recent years.

In general, world prices for corn and rice are around $160 to $200 per metric ton. WFP shipping, local distribution, and monitoring costs amount to nearly $200/ton. Thus, if we assume an annual grain import requirement of 900,000 tons, and assume that half is donated through the WFP, then the cost of that grain is around $162 million annually, plus around $90 million for aid administration.

An alternate approach would be to import the additional fertilizer needed to produce the grain. If we assume that 120 kg/ha of nitrogen would be enough to meet the yield targets for food self sufficiency—considering only the area planted to rice, corn, and other small grains during the main season—then around 136,000 tons of nitrogen would be required (300,000 tons of urea fertilizer). The cost to deliver that fertilizer to the border (Sinuiju or Nampo) would be at least $85 million annually. Local distribution costs (and perhaps monitoring, if the fertilizer were donated) would be added. Phosphate and potash fertilizers are not considered here because they would still be needed under the reformed cropping model proposed. Donating fertilizer would enable the production of enough food to meet the FAO minimal requirement, but would be neither economically or environmentally sustainable.

Costs of Agricultural Restructuring

The agricultural model described in this paper requires a substantial investment in seeds and selected small farming equipment. We can estimate the cost of this investment based on certain assumptions about phased implementation, suitability of land for irrigation, and necessary numbers of specialized farm implements or tractors. In modeling this transition, I assume the following:

- Use of green manure cover crops will initially require importing enough seed for 20 percent of the land area affected. Farms will produce seed for continuation and expansion of the area on their own.
- Rotary disk plows will be needed to plow down most cover crops. At 3 ha/day, one plow will be needed for every 60 ha in order to insure land preparation within a three-week period.
- Small grain drills will be used for wheat, soybean, corn, and some cover crops. Maximum demand would be at the time of planting corn or soybean. At 3 ha/day planted, and a three-week planting period, one drill will be needed for every 60 ha of corn land.

Assuming all current corn fields are rotated with soybean (having a somewhat later planting date), enough grain drills will therefore be needed to plant about 250,000 ha per crop.

- Rotary plows and grain drills can be pulled by the existing Chollima tractors, but these are well past their useful life, have very low fuel economy, and are underpowered. Therefore replacement of the entire farm stock with somewhat more powerful tractors is desirable. We assume one 50hp tractor for every 60 ha of grain cropland. Having more powerful tractors would also speed green manure plowing and crop seeding operations beyond the above estimates.
- Movable rice threshers can process about one ton of grain per hour, or 10–12 tons/day. As rice yields increase, the output rate will rise somewhat because of more grains per rice stalk. We therefore assume production of about 2 ha/day, and a need for one thresher for every 60 ha, in order to accomplish harvest threshing within a one-month period.
- Not all rain-fed fields will be suitable for supplemental spring irrigation. We assume that approximately half the area (250,000 ha) can be irrigated economically. One portable pump and sprinkler line, if carefully managed, can adequately irrigate 5 ha through early June. Small fixed pumps with buried lines and movable sprinklers can be designed easily to irrigate 15 ha.
- The modeled use of small trucks for farm haulage can be met by providing one eight-ton truck for every 180 ha of cropped land.

Table 5. Cost Estimate for Agricultural Restructuring

Item needed	Area served/ unit (ha)	Area to supply (1000 ha)	Units needed	Cost/unit ($)	Total cost ($1,000)	Notes
Green manure seed (ton)	33	227.6	6897	$1,550	$10,690	Supply 20 percent area initially
Rotary disk plows	60	1138	18967	$700	$13,277	For total crop land
Grain drills	60	250	4167	$1,500	$6,250	For half rain-fed grain land
50hp tractors	60	1138	18967	$5,000	$94,833	
Movable rice threshers	60	583	9717	$2,100	$20,405	
Seed cleaner	500	1138	2276	$3,000	$6,828	
Irrigation systems	15	250	16667	$10,000	$166,667	For half rain-fed grain land
8T trucks	180	1138	6322	$16,000	$101,156	
Total					**$420,106**	

Working from these assumptions, the materials needed and their estimated cost are summarized in Table 5. The total cost of seed and capital investment is around $420 million. If we make another simplifying assumption—that the cost of administering a program of aid and investment of this scope, including training and extension of new farming methods, is on the same order as the capital investment—then we arrive at a total cost of around $840 million. This total is less than the cost of four years of food aid, or about the total cost of ten years' worth of nitrogen fertilizer for the DPRK. The results of implementing such an investment and restructuring program would be short-term food security for the DPRK, at a cost much lower than the continued provision of food aid. Such a significant restructuring would require at least five years, and perhaps longer, to accomplish. Investment could therefore be gradual, allowing for local knowledge to accumulate on how best to accomplish and implement the changes outlined here.

Political and Policy Issues

The program of agricultural reorientation described in this paper is not insignificant, and raises concerns that go beyond technology and economics. Who can fund such an effort? Does contributing to DPRK food security provide support to a government that many see as reprehensible? What institutional changes will the DPRK accept?

Certainly, funding an $840 million investment in North Korean agriculture is for neither the faint-of-heart nor for those expecting a rapid return on their capital. The additional food produced through this program will be almost entirely consumed within the DPRK, and will generate little or no convertible currency surplus to return to investors. Thus, the recapitalization of the farm sector must rely either on aid donations or highly concessional loans. That being said, the amount required is of the same order of magnitude as the aid that has been supplied for the past nine years. It also meets the DPRK's requirement that new aid be developmental, rather than humanitarian.

Some will no doubt argue that investing in DPRK farm production will provide "inappropriate support for a corrupt dictatorship." An answer to this challenge requires consideration of the process of agricultural aid. The recent DPRK position on development assistance may well reflect interest in getting off the international dole and accomplishing the institutional changes that the DPRK needs in order to become an economically functional nation. A more cynical interpretation would be that the government believes that humanitarian aid is tied to unwanted monitoring, but that development would not require monitoring. The DPRK idea of "development" currently seems to encompass the provision of turn-key factories or selected foreign investment operations—as was done between 2000 and 2003 in an attempt to modernize the poultry production industry, and is being done now in the Kaesong zone. The poultry project clearly demonstrated that purchasing modern physical facilities is no substitute for good animal management, carefully formulated and high quality feed, and aggressive disease control. Results have been less than optimal, and the recent avian influenza outbreak reminds us of the continued management required for intensive livestock production.

In fact, good development assistance actually requires much more interaction between client and donor than does relief aid. Productively implementing the changes outlined here will require much more than the mere provision of seed, implements, and tractors. Substantial contact and information exchange will be necessary between international technical specialists and North Korean technicians, scientists, and administrators. Without these exchanges, a program like the one outlined here will not be possible. Farm managers will need to learn new patterns of production and new priorities; technical staff will need to learn new techniques and new ways of evaluating their activities. For the changes to be sustainable, farms will need the ability to accumulate the surplus income generated by sale of increased production at open-market prices, so they may spend it on repair parts, other capital investments, and production inputs.

In short, implementing such a development program will require substantial changes in the way the DPRK interacts with the outside world—both technically and economically. It will require—or more precisely, elicit—internal changes in the economy, as farms act to take advantage of changing opportunities and circumstances. I have already seen evidence of these changes: farm managers now discuss not only the relative production of corn and soybean, but also the differential market price of each, and whether the gross return from a hectare of corn (5 tons at 390 won/kg) is more or less than the gross return from a hectare of soybean (2.6 tons at 600 won/kg). One farm manager even included the relative costs of production (soybean is not fertilized) in his calculations. An understanding of market exchange has finally begun to reach the DPRK.

Assisting the DPRK in attaining food security, and specifically food self-sufficiency, will not directly resolve other crucial issues related to nuclear weapons and international relations. However, I would argue that cooperation of this kind would have several important benefits. First, it would establish an arena for increased and improved dialogue about relatively nonsensitive topics, and also facilitate the DPRK's increased participation in international discourse. Second, it would be a confidence-building measure in diplomatic terms. That is, food security would enhance the DPRK's larger sense of security—not in military, but economic terms. Third, it would stimulate progressive changes in domestic economic activity and economic thought. And finally, it would give the DPRK another point of contact and economic exchange with its neighbors, which would in turn provide immediate trade and knowledge benefits.

Will the DPRK accept such a proposal? Certainly they would welcome the hardware, but whether they would accept the related changes in farm orientation and an implicit recognition of the failure of prior "magic bullets" (potatoes, goats, fish ponds, and industrial chickens) is another matter. The recent policy that all currently resident international NGO aid programs must remove their staff from DPRK by January 2006 does not suggest that the government is interested in increased technical or economic exchange on an equitable basis. Current rigid requirements that each farm plant specified areas to certain crops makes it exceedingly difficult for farms to produce green manure seed or to expand crop rotation practices. Giving farms freedom to make their own cropping and investment decisions is risky in a country predicated on total central control over nearly every individual action. The farms are already making some management decisions within gradually relaxed policy constraints, but will need even more economic and management flexibility if the program outlined here is to be effective. With luck, the DPRK government will encourage and support reasonable increases in sustainable productivity, rather than standing in the way in the name of central planning and a misguided application of "*juche* agriculture."

Conclusion

The changes proposed in this paper should not be considered a detailed blueprint for action, but rather a vision, and a policy orientation that must be tested and modified during its implementation. We know too little about farming conditions in the DPRK to make detailed recommendations. However, we know enough to understand that a radically different kind of farming is possible, and that with appropriate technical and material support, it can be implemented relatively quickly and sustainably. We also know enough to believe that such a reorientation can—at the very least—come close to providing self-sufficient food production for the North Korean people.

The DPRK could become, in the foreseeable future, nearly self-sufficient in food production. Doing so would require substantial changes in economic structure, internal and external trade, and attitudes toward autarchy. Such a process would also probably improve their relations with other countries in the course of aid and development. Food self-sufficiency would, to be sure, be at a low level, but much better than it is today.

This process would be collaborative, and based on the exchange of information and ideas. To be effective, it would have to be decentralized, with each region developing appropriate adaptations to a general model of agriculture production. The farm sector would need substantial capital investment to restart the production process, but this is investment with virtually no military potential, which would improve North Korea's sense of security. Finally, the revitalization of agriculture would lessen the country's isolation, as agricultural scientists, farm managers, and farm industry personnel steadily gain options to communicate and trade with organizations outside the DPRK.

Notes

The ideas and opinions expressed in this paper are my own, and do not necessarily represent the positions or policies of the American Friends Service Committee.

1. Western farming practices have of course been affected by different government policies such as price supports or cropland reserves, and the environmental effects of agriculture have not always been benign.

2. Brad Martin relates a similar story. (Martin 2004: 157–58)

3. Importing energy and materials for farming on market terms does promote a certain concern for utilization efficiency and may prevent some of the worst excesses that have characterized DPRK farming practice. In the long run, however, *any* agriculture production system that depends more on the use of fossil resources (fuel, petrochemicals, etc.) than on sustainable processes (e.g., biological nitrogen fixation and pest control, solar and hydro energy development) will eventually experience the same crisis as the DPRK. Elaboration of this point is beyond the scope of this paper, however.

4. In calculating grain equivalent, the FAO converts paddy (unmilled) rice to grain at 65 percent, and potatoes to grain at 25 percent, accounting for moisture content. Corn, wheat, and other small grains are counted at raw weight.

5. Other organizations supporting research and development of green manure systems include the Swiss Agency for Development and Cooperation, German Agro Action, the Australian Centre for International Agricultural Research, and the FAO.

References

Central Bureau of Statistics. 2005. *DPRK 2004 Nutrition Assessment: Report of Survey Results*. Pyongyang: Institute of Child Nutrition.

Choi, Sunchul and Stan Phillips. 2005. "Korea, Republic of: Grain and Feed North Korea Agricultural Situation 2005." Washington, DC: USDA GAIN Report K55024.

FAO. 1999. *Special Report: FAO/WFP Crop and Food Supply Assessment Mission to the Democratic People's Republic of Korea*. Rome: Food and Agriculture Organization.

FAO. 2003. *Special Report: FAO/WFP Crop and Food Supply Assessment Mission to the Democratic People's Republic of Korea*. Rome: Food and Agriculture Organization.

FAO. 2004. *Special Report: FAO/WFP Crop and Food Supply Assessment Mission to the Democratic People's Republic of Korea*. Rome: Food and Agriculture Organization.

Higa, Teruo. 1996. *An Earth Saving Revolution*. Tokyo: Sunmark Publishing.

Iowa State University. 2001. "Roundup ready and conventional soybean yield trial." http://www.ag.iastate.edu/farms/2001reports/ne/RoundupReadyYieldTrials.pdf. URL accessed March 8, 2005.

KCNA. 2005. "Joint New Year Editorial." Pyongyang: Korean Central News Agency. As reported on http://www.kcna.co.jp/index-e.htm, January 2, 2005. URL accessed March 8, 2005.

KCNA. 2006. "Joint New Year Editorial." Pyongyang: Korean Central News Agency. As reported on http://www.kcna.co.jp/index-e.htm, January 2, 2006. URL accessed February 5, 2006.

Kim Soon-Kwon, Lee Kwang-Soo, Han Hyung-Jai, Kim Park, Kim Hyung-Wook, Lee Joon-Soo, Kim Young-Hwan, Jo Kyung-Geun, Min Hwang-Gi, and Lee Myoung-Hoon. 2004. "Combating hunger in North Korea through super-corn development and science-based sustainable farming system." Poster presented at 4th International Crop Science Conference, Brisbane, Australia. http://www.regional.org.au/au/cs/2004/poster/2/3/375_kimsk.htm. URL accessed March 8, 2005.

Kim, Woon-Keun. 1999. "The Agricultural Situation of North Korea." Food and Fertilizer Technology Center, Taipei. http://www.fftc.agnet.org/library/article/eb475.html. URL accessed March 8, 2005.

Korea Meteorological Administration. 1995. *Pukhan kisang 20 nyonpo—20 Year Report of Meteorological Observations in North Korea 1973–1994*. Seoul: Korea Meteorological Administration.

KREI. 1999. *Agriculture in Korea 1999*. Seoul: Korea Rural Economic Institute.

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Kwon Tae-Jin. 2005. "Agricultural Policies under Reform in the DPRK." Seoul: Institute for Far Eastern Studies, Kyungnam University Forum No. 05-7-13-1.

Kwon Tae-Jin, Kim Yeong-Hun, Jeong Jeong-Kil, Pak Jun-Gi, Ji In-Bae, and Kim Yeong-Yun. 2005. *Pukhan-ui Nong-eop pumun kaehyeok-kaepang jeongchaek-kwa nam-buk hyeop-ryeok* (Strategies for Agricultural Reform in North Korea and Inter-Korean Cooperation). Seoul: Korean Rural Economics Institute.

Lemaire, Christian. 1999. Personal communication.

Lundberg Farms. 1998. Personal communication.

Martin, Bradley. 2004. *Under the Loving Care of the Fatherly Leader.* New York: St. Martin's.

Nelson, L.A., R. N. Klein, R. W. Elmore, D. D. Baltensperger, C. Shapiro, S. Knezevic, and J. Krall. 2004. "Nebraska 2004 Corn Variety Test Results, Otoe County." Plant Management Network: www.plantmanagementnetwork.org/pub/cm/trials/2004/corn/Nelson.xls. URL accessed March 8, 2005.

Noland, Marcus, Sherman Robinson, and Tao Wang. 2001. "Famine in North Korea: Causes and Cures," *Economic Development and Cultural Change* 49 (4): 749ff.

Noland, Marcus. 2000. *Avoiding the Apocalypse: The Future of the Two Koreas.* Washington, DC: Institute for International Economics.

O Dae Ho. 1986. *Experiences in Rural Technical Revolution.* Pyongyang: Foreign Languages Publishing House.

OCHA. 2005. *DPRK: Situation Bulletin.* No. 01/05. December 2004/January 2005. Pyongyang: UN Office for the Coordination of Humanitarian Affairs.

Schäfer, Bernd. 2004. "Weathering the Sino-Soviet Conflict: The GDR and North Korea, 1949–1989." *Cold War International History Project Bulletin: 14/15:* 25–85.

Smith, Heather. 1998. "The Food Economy: The Catalyst for Collapse?" pp. 53–75 in Marcus Noland, ed. *Economic Integration of the Korean Peninsula.* Washington, DC: Institute for International Economics, Special Report 10.

Stanley Foundation. 2005. "Future Multilateral Cooperation with the Democratic People's Republic of Korea." Conference Report. Berlin, June 15–17, 2005. Stanley Foundation and German Council on Foreign Relations.

Szalontai, Balázs. "You have no political line of your own: Kim Il Sung and the Soviets, 1953–1964." *Cold War International History Project Bulletin: 14/15:* 87–137.

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