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The co-expertise experience of upland sheep farmers in the UK after the Chornobyl accident

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Abstract

Deposition of radioactive caesium after the Chornobyl accident affected upland areas of the United Kingdom, where the practice of non-intensive sheep farming prevailed. Restrictions were placed on the marketing of sheep meat from these areas for 26 years, which severely impacted the traditional way of life of the affected farmers. The initial flawed response from the UK government took a top down, bureaucratic approach, which ignored the specialist local knowledge and expertise of the farmers, thereby undermining their autonomy. Over a period of many years, collaboration between farmers, local officials, independent scientists, and others enabled a co-expertise process to be developed. Measurements were a key element of this process that enabled consumer confidence to be maintained, whilst also bringing empowerment and dignity to the farmers by involving them in the taking of measurements and subsequent discussion of the results. This chapter discusses a range of approaches that were taken to facilitate stakeholder engagement, and how the adoption of a more holistic approach to risk was fundamental in removing the long-standing restrictions on sheep farming.

1. Historical context

In the late 1980s and early 1990s there was a crisis of confidence in the quality of food from the United Kingdom (UK) and a lack of credibility in the Ministry of Agriculture, Fisheries and Food (MAFF), following a wave of food scares including outbreaks of Bovine Spongiform Encephalopathy (BSE), Salmonella, and E-coli. BSE and its human equivalent, variant Creutzfeldt-Jakob disease (vCJD), was first identified in November 1986 and subsequently over four million head of cattle were slaughtered to contain the outbreak, and 178 people

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died after contracting vCJD through eating infected beef. It was during these challenging years that the Chornobyl accident impacted the UK.

Heavy thunderstorms on 2-4 May 1986 and again on 7 May, brought radioactive contamination from Chornobyl, located 4000 km away from the UK. Very high levels of deposition were found mainly on upland areas of the UK (Figure 1).

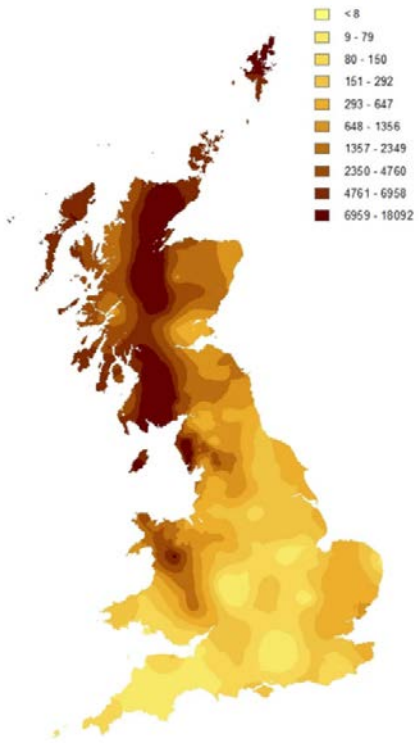

Figure 1. Chornobyl fallout over Great Britain in May 1986
(^{137}Cs activity concentrations in graminaceous vegetation, Bq/kg dry matter)
(from J. Chaplow, N. Beresford and C. Barnett, 2015).

During the first few weeks, public confusion and anxiety were met with bland assurances from Government that there was no risk to health. On 13 May, MAFF found samples of lamb (sheep meat) from Cumbrian fells in Northwest England, had levels of radiocaesium of 1,500 Bq per kg, which was 50% greater than the UK (and European Commission) action level of 1000 Bq per kg (caesium-134 and caesium-137). On 20 June, under powers within the Food and Environment Protection Act (FEPA) 1985, MAFF announced an immediate 3-week ban on the movement and slaughter of sheep in parts of Cumbria and upland areas of North Wales. Similar restrictions were placed in Scotland on 24 June. The number of farms and sheep originally under restrictions is given in Table 1. More than 4 million sheep and ~9,000 farms were affected in the UK. This represented about one fifth of the UK sheep population.

TABLE 1. Initial numbers of farms and sheep under restriction in June 1986.

	England	Wales	Scotland	Northern Ireland
Farms	1,670	5,100	2,900	122
Sheep	867,000	2,000,000	1,358,000	53,000

Radiocaesium is excreted rapidly by lambs and every 12 days the concentrations decrease by ~50%. Therefore, it was assumed that it would take no longer than 3 weeks for activity concentrations to be less than the action level. The short-lived restrictions were based on the scientific belief that radiocaesium would become immobilised in soil and not incorporated into new grass. This was based on research on lowland clay mineral soils. However, the upland soils were mainly acidic, with a high organic matter content. As such, it was likely that the radiocaesium would remain chemically mobile and be available for uptake by pasture and grazing animals over many years (decades). On 24 July 1986, an indefinite ban was placed on the movement and sale of lamb from restricted areas in UK. This was serious as hill farmers potentially faced ruin, not only due to restrictions on lamb, but also breeding flocks faced starvation and wholesale slaughter, due to inadequate supplies of fresh pasture.

By August 1990, the number of restricted farms and sheep had fallen significantly with a reduction of around 90% in the number of farms in England and Wales subject to restrictions. Nevertheless, these data changed very little over the next 10 years with only a further 4% reduction in the number of restricted farms. The long duration of the restrictions impacted greatly on the affected farmers and their traditional way of life.

Upland lamb is highly prized for its distinctive, complex flavour and beneficial nutritional properties, which stem from the sheep's varied, natural diet, non-intensive farming methods and lifestyle in rugged environments (Figure 2). Upland lamb is a unique product that is irreplaceable, both in terms of quality and cultural significance, by sheep from other regions or other foods.

FIGURE 2. Upland sheep farming terrain (photo: Tony Richards).

2. The response by the authorities

On 18 August 1986, in response to the problem of overgrazing, the Government introduced a monitoring programme called Mark and Release, which permitted farmers to sell and move contaminated sheep from the restricted areas. This *in vivo* method for measuring radiocaesium was developed by experts over a period of around 6 weeks, for application on the farm (Figure 3). Sheep with measured concentrations of radiocaesium above the action level were classed as failures and were colour-marked with indelible paint: they could be moved or sold at any time but not slaughtered until they were remonitored. Sheep with activity concentrations less than the action level had to be kept on improved pasture, which had lower levels of radiocaesium, prior to sale. In addition to the routine Mark and Release monitoring programme, derestriction surveys were carried out on a few carefully selected farms to investigate whether farms could be permanently released from restrictions. These surveys were conducted in the summer months when activity concentrations of radiocaesium were known to be at their highest. Every sheep on the farm was monitored within 24 hours of coming off the upland pasture. Derestriction surveys provided a reliable means of identifying farms where activity concentrations of radiocaesium in lamb were less than action levels. The surveys were widely accepted by farmers as a way of returning to their normal farming practices, confident that the levels of radiocaesium in their flock were no longer of concern.

FIGURE 3. Mark and Release monitoring on restricted farms (© Crown copyright 2007. Source: Food Standards Agency. Licensed under the Open Government Licence v3.0.).

Slaughterhouse monitoring was used to complement the in vivo techniques that was carried out on live animals. The monitoring took place at ten slaughterhouses that received sheep from the restricted areas in Cumbria and North Wales. In 1989 more than 11,000 carcasses were monitored at these slaughterhouses. Similar numbers of carcasses were monitored in subsequent years. No meat with activity concentration greater than the action level was detected, thus providing reassurance to the authorities that the Mark and Release monitoring programme was effective and reliable. This also gave farmers the confidence that the Mark and Release programme was effective, and that no contaminated lamb was entering the food chain. Ultimately, this provided consumers with the confidence they needed, in the light of so many other food scares at that time.

The impact of the Chornobyl restrictions on hill farmers as well as the financial costs to MAFF, prompted MAFF to support various independent research projects to look for alternative ways to manage the radiological situation (e.g., Beresford et al., 1999; Nisbet and Woodman, 1999). These involved engagement with a wide range of stakeholders, including face-to-face meetings with the farming community, over an extended period. The evolution of this engagement (latterly known as co-expertise) process is described below (Section 4). However, despite numerous initiatives it was not until 1 June 2012, following a public consultation, that all Chornobyl restricted areas were released from restrictions.

3. The human dimensions of the situation

The initial response from the UK Government took a top-down approach, to inform the affected farming communities about what was happening and what they needed to do. The period between 1986-1990 was the most challenging due to the number of farms and sheep affected. The upland hill farming community has a distinctive traditional cultural identity. Farming upland areas is economically fragile as the land is marginal for cultivation due to poor soils and difficult terrain. Farmers have few if any alternatives to make a living, compared to lowland sheep farming. The normal practice on hill farms is for lambs to be brought off unimproved grazing to improved lowland pasture for a 3-week fattening period before being sold directly for slaughter. In 1986, when farmers were told by Government to keep sheep on the farm until levels of radiocaesium fell, their hill farm system couldn't easily be adapted to cope with this demand, as insufficient pasture was available. In interviews carried out by the BBC (BBC, 2011), one Welsh farmer said, "we were told, and presumed, that the whole issue would be over and done within a matter of weeks or months" and another remarked, "it was a huge battle to get the Government to realise the severity of the problem".

Farmers felt betrayed by bureaucrats and scientists because their own specialist local knowledge and expertise were ignored e.g., farmers were asked to hold on to their sheep which impacted their physical condition and market price (Wynne 1989). Pinpointing the optimum moment for marketing lambs is key to successful sheep farming. Complex craft judgments of trends in prices, rates of finishing of other lambs, pasture conditions, disease buildup, condition of breeding ewes for mating for next year's lambs, need for money (cash flow), and

many other dynamic factors partly or fully beyond the control of the farmer, enter into these decisions. It is an informal but highly sophisticated process involving expert judgement, which runs counter to the bureaucratic advice to sell the lambs later. Furthermore, sale of spring lambs provides hill farmers with their only significant yearly income. One farmer from Cumbria remarked, "we were told we could not sell our lamb. This caused problems of cash flow".

Farmers' autonomy was undermined by how the restrictions were implemented, i.e., the restrictions required farmers to notify the local MAFF offices at least 5 days in advance of their intention to sell a certain number of sheep and to identify the market. The farmer had to give notice to allow the monitoring session to be scheduled and had to wait with the sheep on the appointed day. The farmers spent extra time gathering and handling sheep which worsened their condition and affected their value. The farmers reflected "It has been a real struggle. Our daily lives are much harder; I can't just take my sheep to auction".

In those initial few years after the accident the sheep farmers felt that their social identity as a specialist community with distinct traditions, skills and social relations was under fundamental threat, due to impractical interventions proposed by the authorities (Wynne, 1992). Scientists and MAFF officials were often seen as indistinguishable as one defended the other. Later claims from farmers for compensation encountered the inflexible bureaucratic demand for formal documentation, dates, details, proofs, and signatures that were alien to their own culture.

In the late 1980's, Wynne (1992) and colleagues carried out in-depth interviews with hill sheep farmers in the restricted areas of Cumbria. From these interviews it became apparent that Government scientists expressed a certainty in their official statements that simply did not ring true with the farmers who were used to adapting to uncertain and unpredictable forces. The degree of certainty expressed in scientific statements, the unqualified reassuring assertions, and failure to admit mistakes led to a lack of trust and credibility amongst the hill farmers. Critical to the experts' lack of credibility was their inability to recognise that farmers held extensive informal knowledge about sheep habits, the local physical environment, and farming practise and decision making, all of which needed to be integrated with more abstract and formal scientific knowledge to create an effective response framework to the Chornobyl deposition. Nor did the experts recognise the cultural and practical incompatibility of hill farming with the bureaucratic model in which everything is assumed to be subject to standard rules, control, deterministic planning, and formal evidence (Wynne, 1989).

The situation in Cumbria was further complicated by its close proximity to the former Windscale nuclear weapons factory and existing nuclear reprocessing facility at Sellafield, both located on the coast below the upland pastures affected by the Chornobyl accident. Both nuclear facilities were known to have released radioactivity into the environment due to a major fire at Windscale in 1957 (Garland and Wakeford, 2007), and routine discharges from Sellafield. Whilst historic measurements of radioactivity were available for the coastal strip, none had been made in the nearby uplands. It was therefore not surprising that Cumbrian farmers wondered whether the source of contamination affecting

their farms was actually from Windscale or Sellafield, not Chornobyl. At this time, their level of trust in Government scientists was very low.

Evidence of a generational divide existed among the affected sheep farmers, primarily concerning differences in their perception of the risks, their trust in official scientific advice, and their views on the long-term impact on their way of life. While acknowledging the difficulties, some of the younger generation, who grew up with the restrictions as a "necessary evil," viewed the testing and monitoring as essential for bolstering consumer confidence in the long-term. Some also showed a greater acceptance of the low-level, long-term nature of the risk, often contrasting their minimal misfortunes with the severe impacts on Ukrainians closest to the disaster. Nevertheless, the prolonged uncertainty and economic fragility of hill sheep farming, partly exacerbated by the restrictions and fluctuating compensation payments, made the lifestyle less appealing to the younger generation. Many children of the original affected farmers chose different professions (e.g., joiner, electrician, chef). This reluctance to continue the family business points to a significant break in the multi-generational tradition of hill farming, driven by the difficulties faced by their parents' generation.

4. The co-expertise process

4.1. *Initial engagement*

It is within this challenging context that, farmers progressively engaged and cooperated with experts, first with monitoring teams through the Mark and Release scheme and then when derestriction surveys were carried out. The farmers appreciated the role and importance of measurements in supporting their farming practices and in maintaining consumer confidence in upland lamb, including several important brands. The farmers assisted the monitoring teams and discussed the measurement results with them, and what the numbers signified and any implications. In this way they felt empowered and that their dignity had been restored.

The farmers also connected with scientists who visited farms for monitoring, sampling, and research purposes. Some of these scientists stayed for several days and engaged in more informal dialogue/ conversations about their scientific research. These ad hoc interactions improved the credibility of these scientists and of their associated institutions, even though such encounters revealed scientific uncertainty. The Institute of Terrestrial Ecology (ITE), a locally based institution gained a reputation among the farmers as being plain speaking, open about uncertainty, independent, and trustworthy. Scientists from ITE lived in the area and understood the challenges faced by upland farming. In the first few years following the Chornobyl accident, a cooperation was progressively built between farmers, local farming union officials, local MAFF officials, local auctioneers and independent scientists from the nearby research establishment. Whilst the credibility of some scientists improved, and a certain level of trust was established with local officials, the opposite was true for MAFF, which was more centralised, hierarchical, geographically, and culturally remote.

Farmers quickly learned to distinguish and evaluate the different institutional affiliations. A deep mistrust remained of central Government which persisted throughout (Wynne, 1989).

Farmers also developed special relationships with representatives of the local farmers' union, local MAFF officials, and local auctioneers, all of whom they knew personally and trusted individually. These local representatives were invaluable in advising on how to manage the restrictions on marketing their lambs and on matters relating to compensation payments and related paperwork. The farmers' union successfully pushed the Government hard for compensation payments for price blight on marked sheep and inconvenience and time required for monitoring sheep.

4.2. *Dialogue on alternatives to the restrictions*

Some 10 years later, with the restrictions still in place, another dialogue with farmers took place, initiated by independent scientific experts from the National Radiological Protection Board (NRPB), a non-departmental public body. The main objective of this initiative was to identify alternatives to the monitoring controls (Nisbet and Woodman, 1999), that not only considered the views of the farming community, but also the wider impact on consumers, environment, and economy. These alternatives included the mandatory use of improved land, the improvement of upland pasture, the provision of clean feed to finishing lambs; the provision of boli containing Prussian Blue to reduce gut uptake of radiocaesium in sheep; and monitoring at the marketplace. This initiative took place in 1997, involving an extended dialogue and a series of face-to-face meetings with hill farmers and their farmers' union representatives, as well as phone calls, correspondence, and meetings with all other interested parties (including Countryside Council for Wales, National Parks Authority, Country Landowners Association, Tir Cymen, MAFF and Welsh Office Agriculture Department). At the end of the dialogue, it was concluded that many of the proposed alternatives were rejected either by the farmers themselves or other stakeholders, due to the environmentally sensitive nature of the areas, the negative impact on the image of upland lamb as an "organic product", low cost-effectiveness or limited applicability on a large scale (Nisbet and Woodman, 2000). Consequently, sheep restrictions remained in place.

4.3. *Revisiting the risks to consumers*

Questions on the duration of the restrictions continued to be raised by farmers, farming unions and the livestock trade. The Food Standard's Agency (FSA), that had taken over Government responsibility for food safety, reviewed its policy relating to the Chornobyl restrictions during its routine review cycle. As part of this review, the use of the current limit of 1,000 Bq per kg, as a measure of risk was reconsidered. Using a fixed limit of contamination in effect considers that sheep above 1,000 Bq per kg are unsafe and sheep below that level are safe to eat. International guidance published by the International Commission on

Radiological Protection (ICRP, 2007; ICRP, 2009) reinforced the view that protection from radioactivity should consider the actual risk to individuals (measured as the effective dose, expressed as milli Sieverts, mSv) rather than purely relying on a fixed limit of contamination. Therefore, the FSA with the help of independent consultants, carried out an updated risk assessment to consider the actual risk to consumers from eating lamb originating in the restricted areas (Wells, 2011; Field, 2011), noting that ingestion of lamb was the only exposure pathway of significance. During the summers of 2010 and 2011, extensive monitoring surveys were carried out in the restricted areas of Cumbria and North Wales, immediately that the sheep were taken off the upland pasture (this is when radiocaesium levels in lamb are at their peak). The data gathered were used to assess the risk to consumers. The risk assessment calculated the likely dose to the more highly exposed individuals (the so-called representative person). From these results it was concluded that the risk to consumers would be very low, following the lifting of all restrictions. The doses to the representative person range from <0.05 to 0.21 mSv per year with an average dose of less than 0.09 mSv per year. This is considerably below the 1 mSv per year reference level typically used in long-term exposure situations, and the 1 mSv per year limit for members of the public exposed to radiation from routine planned exposures (e.g., nuclear site discharges).

4.4. *Stakeholder workshop*

The findings from the dose assessment were widely disseminated among the farming community and in August 2010 were discussed at a stakeholder workshop attended by individual hill farmers, National Farmers' Union, Farmers' Union of Wales, Hybu Cig Cymru (Meat Promotion Wales), FSA, Department for Environment, Food and Rural Affairs, Rural Payments Agency, and independent radiological protection experts (Health Protection Agency, Centre for Ecology and Hydrology). The meeting was to gather information on which to base policy options. The format was a combination of presentations, plenary discussions and break out groups.

A range of alternative monitoring protocols were discussed at a stakeholder meeting. These were monitoring at the marketplace or slaughterhouse; monitoring sheep for sale or slaughter only; monitoring a representative sample of sheep (e.g., 10% of each movement). The conclusion, after discussion, was that all these alternative monitoring protocols were unsuitable for a variety of reasons (e.g., lack of control or opportunity to remedy the situation; reduced flexibility in marketing practice), as well as the very low risk to consumers of meat from the restricted areas.

Stakeholders identified the following factors that needed to be considered before the restrictions could be lifted: health risk; impact on consumer confidence; impact on the market value of sheep; cost; the decision-making process; and the method of communicating the decision. Overall, consumer's perception of health risk was the most important single factor. What consumers tolerate in terms of risk is down to the comfort they receive from the information presented

to them. It was felt important that there should be robust evidence that lamb was safe to eat, that there was agreement among experts that this was the case. However, given that the topic is both complex and sensitive, the way this message needed to be communicated to consumers was very important, to prevent misunderstanding. Handled badly, there would be a risk that the product could be devalued, should media reports convey either the wrong information or misinterpretation of the facts. A clear and unified approach to communication was felt necessary to maintain confidence in the meat industry, that had developed several important brands which needed to be protected. There was a need for all stakeholders including the FSA, other Government and non-Government experts, farming unions and the meat industry to work together to produce a series of consistent messages.

4.5. *Public consultation*

The outcomes of the stakeholder workshop and informal discussions with farming unions, meat industry representatives and radiological experts, were used to inform a public consultation document that was launched by the FSA on 17 November 2011 (FSA, 2012). The FSA asked consultees for any evidence that would alter the assessment that the risk to consumers of lamb from the restricted areas was low. The overall objective was to ensure that the removal of restrictions was risk based, proportionate and that consumer safety was not compromised. In particular, FSA asked for feedback on the cost: benefit analysis that had been undertaken and whether any information on other costs or benefits had been missed. The FSA received 15 responses to its 12-week UK-wide public consultation from a variety of organisations, including the farming unions, meat industry, Health Protection Agency and Cumbria County Council. Individual farmers from the restricted areas also responded. The results of the public consultation are given below.

5. Evolution of the co-expertise process

In the years following the Chornobyl accident, the co-expertise process evolved, and relationships between almost all stakeholders were much improved, although a deep mistrust of central Government remained. The co-expertise was built between the upland hill farmers and their farmers' union representatives, local MAFF officials, local auctioneers, and a range of independent scientists who visited the restricted farms regularly. Involvement with local representatives, familiarization with the monitoring program and ability to discuss the results, all helped to regain the farmers' dignity and empowerment, slowly attitudes changed.

A wider network of stakeholders also became engaged in the process, as the affected farms were in areas of outstanding natural beauty, and some were within Snowdonia National Park in North Wales; some alternatives to the restrictions had the potential for adverse environmental impact. Furthermore, the reputation

of upland lamb as a high quality, much sought after product, led to engagement with meat industry representatives such as Farm Assured Welsh Livestock and the National Sheep Association to voice concerns over some of the proposed interventions. Ultimately, the co-expertise process in the first 20 years after the Chornobyl accident, overwhelmingly favoured maintenance of the status quo, that is continuing the Mark and Release scheme, whereby every sheep from the restricted area was monitored prior to being sold or slaughtered. Publication of recommendations by ICRP in 2007 and 2009, challenged this approach.

Reference levels (in terms of annual effective dose) were considered to be the more appropriate radiological criteria to use when optimising consumer protection in the longer term. Previously, action levels (in terms of activity concentration in a foodstuff) had been correctly applied in the immediate aftermath of the Chornobyl accident and then retained without question, in the years that followed. Furthermore, new models to better understand risks to consumers based on measurement data were developed, supported by intensive monitoring surveys of sheep in restricted areas. The doses to the representative person were predicted to be well below the reference level recommended by ICRP (2009) for the long-term phase after a large nuclear accident. Consequently, FSA and other independent bodies with an interest in food safety, considered that (i) the restrictions were no longer proportionate to the very low risk, (ii) that they were ineffective at further minimising the already low doses and (iii) that by removing controls, consumer safety would not be compromised.

Responses from the public consultation were published on 20 March 2012 (FSA, 2012). FSA's final evidenced-led conclusion was that removing controls would not compromise consumer safety. The FSA Board supported the conclusion and all Chornobyl-based restrictions on sheep in the UK were removed on 1 June 2012. The responses were generally supportive of the risk assessment and agreed with the conclusions that there was a very low risk to consumers and that controls were no longer required to protect consumer safety. However, a few Welsh farmers were concerned that consumers may not understand the discussion about risk, and as a consequence, the reputation of Welsh lamb could be damaged. FSA officials attended meetings with farming union officials and farmers in North Wales, both before and during the consultation period. Feedback from these events stressed the need for a carefully constructed consumer engagement process to accompany the removal of controls, which was seen as vital to mitigate or respond to negative portrayals in the media.

The public consultation received coverage in both the local and national media, including prime-time national TV. The FSA received no adverse comment from consumers. In implementing the policy, FSA continued to reinforce the message that risk to consumers was very low and removing controls would not compromise consumer safety. FSA continued to work with the farming unions and meat industry on a joint platform and provided information and comment in their publications in order to provide context to explain the very low risk. Feedback indicated that more could still have been done to explain the relationship between activity concentrations (Bq per kg) and risk.

In the years after the Chornobyl accident, the UK Government became increasingly aware of the need to engage with stakeholders on all matters relating

to food safety. In light of the farmers' experience following the post-Chornobyl sheep restrictions, scientists from NRPB recommended that a stakeholder group be established to develop strategies for managing agricultural land following a radiation emergency. In 1997, the Agriculture and Food Countermeasures Working Group (AFCWG) was established (Nisbet and Mondon, 2001), comprising a wide range of Government and Non-Government Organisations, the latter encompassing consumer and environmental groups, retail trade, producers and processors, and farming unions. Subsequently, based on the success of the AFCWG and with funding from the European Commission, the concept was extended through the FARMING project to other European Member States (Nisbet et al., 2005).

6. Main lessons learned for the co-expertise process

The experience of the UK sheep farmers affected by Chornobyl restrictions, was not, at the start, a co-expertise process. Over the years a co-expertise was developed between the farmers, local officials, and experts, and during this period many lessons were learned, which are further discussed below.

i. As soon as the upland areas of the UK were known to be affected by Chornobyl deposition, there needed to be recognition from central Government that the farming community in those areas had something valuable to contribute and were worthy of acting as co-experts with the authorities. There was a need for the authorities to engage sooner not only with the farming community but more widely as many stakeholders were affected by the restrictions. The considerable disruption and pain suffered by those affected in the first year would have benefited from a more empathetic approach from Government representatives. Regular engagement is key and unfortunately too many years were allowed to elapse between different initiatives. Nevertheless, through the involvement of local officials and independent scientists, relationships were progressively rebuilt, and a certain level of trust was established with the authorities.

ii. Government officials and scientists needed to admit uncertainty (e.g., on the timescales for when the restrictions could be lifted) and be humble and open to other sources of local information and knowledge. At the time of the Chornobyl accident, there was a deeply embedded assumption that lay people couldn't handle uncertainty and risk, which resulted in false reassurances from Government about the situation. Communication was perceived by farmers as an add-on to decisions that were made, providing post-hoc explanation and justification. A better approach might have been for officials to acknowledge that their backgrounds were not sufficient to address the complexity and challenges posed by radioactive contamination of upland sheep farms. The value of farmers' own expertise and local knowledge needed to be recognised and integrated into the response to the mutual benefit of all parties. Farmers' expertise is not written down but passed on orally and by apprenticeship from one

generation to the next, as a craft tradition. This required experts to listen and learn from the farmers, to get to know them and their practices and to demonstrate commitment to improving their situation in the long term.

iii. The process that was used to assess, and then dismiss, a range of alternative approaches to the long-standing sheep restrictions, worked well. Dialogue with a range of stakeholders including the farming community, provided a broad spectrum of views that enabled a robust decision to be made, taking into account not only radiological concerns but also protection of the environment, and maintenance of economic and societal activities.

iv. The decision to take a more holistic approach to risk was fundamental in removing the sheep restrictions. In particular, moving from an initial approach based on activity concentrations in lamb to an approach based on estimating effective dose to consumers of lamb, provided a more reliable indication of risk in the longer term. Nevertheless, this new approach needed to be explained and communicated more clearly and perhaps more done in terms of education and training of a wider audience. The holistic approach to risk not only considered the impact of ingesting contaminated lamb but also took into account the social disruption caused to farmers by the restrictions, the economic cost to farmers and Government from enforcing the restrictions, and the environmental impact of the alternative protective actions that were proposed. This ensured doses were kept as low as reasonably achievable.

In conclusion, collaboration between farmers, local officials, independent scientists, and others over a period of many years enabled a co-expertise process to be developed. Measurements were a key element of this process that enabled consumer confidence to be maintained at a time when other food crises questioned the credibility of the Ministry of Agriculture, Fisheries and Food, and the quality of food in the UK. Involving farmers in the taking of measurements and in the subsequent discussion of the results brought empowerment and dignity. Furthermore, the co-expertise process was able to lessen the impact of the Chornobyl restrictions in the UK, maintain sheep farming in the affected areas, and after a period of 26 years, to enable farming practices to return to normal.

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