4. EFFECT OF THE CHERNOBYL DISASTER

The accident and its consequences

The explosion that occurred at the Chernobyl nuclear power plant in the early hours of April 26, 1986 resulted in the world's largest nuclear disaster of the 20th century. The core of reactor 4, an RBMK-type reactor with a graphite moderator, exploded. The impact on Belarus, which at the time formed a part of the Soviet Union, was greater than on any other Soviet republic. The disaster had ecological, demographic, social and economic consequences for Belarus, as the site of the disaster – the nuclear power plant near the town of Prypjat', Ukraine (Pripyat', Rus.) – lay barely a few kilometres from the Belarusian border. Moreover, owing to the weather conditions in the immediate aftermath of the accident, much of the pollution occurred in Belarus. Indeed, 48.8 thousand square kilometres of land in Belarus – 23.5 per cent of its total area (207.6 thousand km^2) – was exposed to radioactive pollution. The Chernobyl disaster affected a larger geographical area than any previous industrial accident, and the effects of the accident have been felt in the long term. Addressing the problems has been a costly task requiring international cooperation. Overcoming the consequences remains a goal of public importance for Belarus.

In the course of the accident, the largest area was polluted by the isotope Cs-137 (Caesium-137) (*Figure 4.1*), which had been released from the reactor. Rainfall washed most of this out of the atmosphere in the following nine days, by which time the graphite fire had been extinguished and work could begin on the construction of a sarcophagus that would encase the ruined reactor. The health problems that arose in people after the accident and which are still prevalent, were caused mainly by the short (~8 days) half-life isotope I-131 (Iodine-131).

After the extinction of the reactor fire, the isotopes with a short half-life, which were extremely harmful to human health, rapidly decayed. A year after the accident, the radiation level was just 2% of what it had been at the time of the accident, and after two years it had fallen to 1% (IAEA 2006). The impact of Cs-137 pollution was felt for a much longer period. Meanwhile, a smaller area – a zone of roughly 30 kilometres around the reactor – was polluted by Sr-90 (Strontium-90), Pu-239 (Plutonium-239) and Pu-240. The Plutonium isotopes have an extremely long half-life. Unlike the aforementioned isotopes, the isotope Pu-241, a significant quantity of which was spilled around the reactor, has a relatively short half-life (14 years), but its decay product, Am-241 (Americium-241) (with a half-life of 400 years), is much more radiotoxic than its parent. This is unique among the emitted isotopes. Moreover, it will reach its maximum concentration a hundred years after the accident (IAEA 2006).

After the disaster it was recognized that Cs-137 would pose the greatest danger for many decades. Accordingly, in the late 1980s, zones were established based on the level of Cs-137 contamination. In Europe, there are 190,000 square kilometres of land where the Cs-137 contamination level exceeds 37 kBq/m^2. These contaminated areas are roughly divided into four equal parts between Belarus, Ukraine, Russia and the other affected European countries (principally, Sweden, Finland, Austria and Norway). Meanwhile, areas where the Cs-137 contamination level exceeds 185 kBq/m^2 are to be found only in Belarus (16,000 km^2), Russia (8,000 km^2) and Ukraine (5,000 km^2) (IAEA 2006).

The **physiological effects** on the human body of the increased radiation that stemmed from the disaster continue to be the subject of scientific and political debate, and there is a wide spectrum of opinions concerning the extent of the effects. An increase in thyroid cancer incidence – caused by the isotope I-131, which has a short half-life – is the only instance where a connection with the disaster has been mathematically proven (IAEA 2006). There is no doubt, however, that the stochastic effect of radiation lies be-

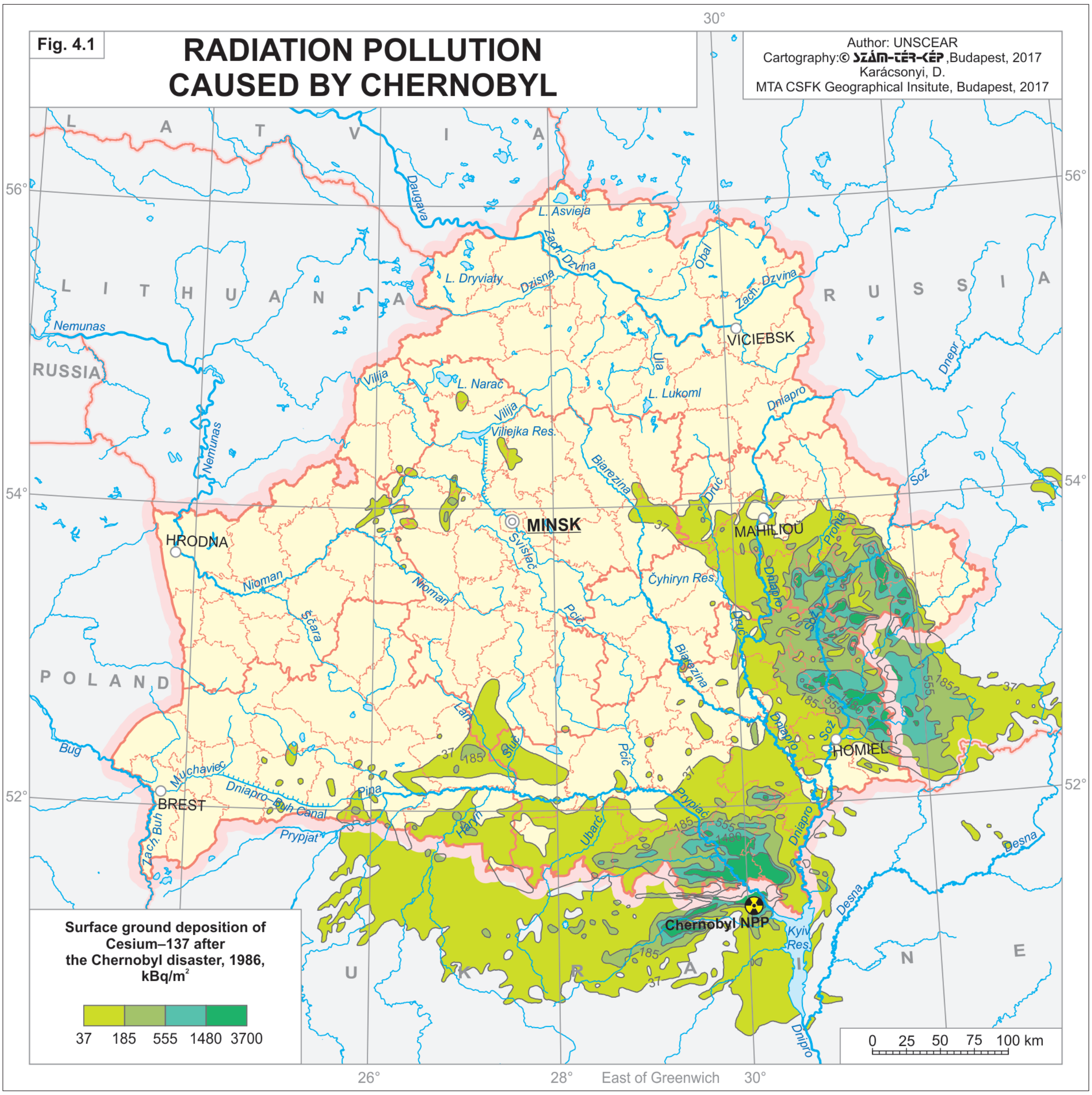


Fig. 4.1 RADIATION POLLUTION CAUSED BY CHERNOBYL

hind some of the cancer and other illnesses that have affected the population since the disaster. Evidently, the role of radiation is very difficult to prove when people fall ill years later and when there are multiple other factors – alcoholism, smoking and stress. Moreover, amid the chaos that followed the collapse of communism, it was almost impossible to distinguish between the effects of the socio-economic crisis and the effects of the crisis situation caused by the nuclear disaster itself (Rumyantseva, G. *et al.*, Lochard, J. 1996, Brenot, J. *et al.* 2000). According to Jaworowski (Jaworowski, Z. 2010), the consequences of the disaster were exclusively psychological, and most of the deaths are attributable to the shock caused by evacuation/resettlement and the accompanying social deviance (e.g. increased crime and alcoholism) rather than to radiation. Greenpeace represents views at the other end of the spectrum. So-called radiophobia is, nevertheless, a subject that has been widely researched (Lochard, J. 1996).

After the disaster, in the final years of the Soviet era, two solutions – or their combination – were employed to mitigate the effects on the local population: radiological decontamination and the resettlement of people in non-contaminated areas. A radiation contamination survey served as the basis for both endeavours. It was only in the end of 1980s that the results of this survey were made public and accessible to all. Many calculations were made for the costs – per person and per household – of decontamination and of evacuation/resettlement. Resettlement, the establishment of new homes, seemed clearly to be more expensive, but it was also the much safer solution (Tykhyi, V. 1998).

The **status of areas affected by the Chernobyl disaster** is regulated by laws, some of which were adopted prior to the collapse of the Soviet Union. Most of the legal regulation, however, was left to the successor states, among them Belarus (Matsko, V.P. 1998). The first (uniform) regulation related to the evacuation area (the 30-km zone). Subsequently, in late 1988, the so-called 350 mSv (milli-Sievert) concept was adopted, whereby decontamination efforts were suspended in those areas where calculations had shown that the local population would receive a 70-year ("lifetime") dosage of at least 350 mSv. Residents of such areas were resettled in non-contaminated areas (Malko, M.V. 1998). The 350 mSv concept immediately became the subject of sharp criticism in Belarus (Malko, M.V. 1998), however in Japan after the Fukushima disaster the temporary evacuation is planned to be lifted where the doses are below 20 mSv per year (!) (Team in Charge… 2013). Given the impossibility of determining the dosage for each person, the calculation was made for the resident population as a whole. This inevitably caused mistrust among people. The general position was that in the mainly rural areas where healthy foodstuffs could no longer be produced, it was futile to compel the local population to stay. Thus, over and above the original concept, the decision was taken in Belarus to evacuate and resettle an additional 100,000 people. This decision was implemented in large part at the very beginning of the 1990s.

The half-life of Cs-137 is around 30 years, which means that 30 years after the disaster the quantity of isotope released in 1986 decreased by roughly a half, and so the radiation levels will also decline significantly over time. As a result of the natural degradation and purification processes, the categorization of the zones will change as time passes. Economic restrictions will be lifted, and the area of the various zones will be reduced. In Belarus, a government-run campaign ("State Program on Overcoming the Consequences of Chernobyl, 2011–2015 and the period to 2020") was launched to rehabilitate the contaminated areas (Jaworowski Z. 2010). The state program aims to create a system for providing state administration bodies and the public with information on the problems arising from the consequences of the nuclear disaster.

The impact on society

The **contaminated areas** are home to 13% of Belarus's population. Almost a half of the people affected live in the city of Homieĺ (*Figure 4.2, Table 4.1*). On January 1, 2008, in the contaminated areas, there were 2,614 settlements with a population of 1.3 million. The Homieĺ and Mahilioŭ regions, which were among the worst affected, had a population of 1.13 million people, or 86% of the total number of the inhabitants of the contaminated areas. Under the urban resettlement scheme, the residents of five towns in the contaminated areas were entitled to resettlement. Twelve additional towns are situated in the zone of periodic radiation control. Only one in three residents in the contaminated areas are rural dwellers; many of these people live in rural areas to the north of Homieĺ.

Even in the absence of the Chernobyl disaster, the Paliessie region would be a peripheral and depressed region with substantial out-migration (*Box 4.1*). Life has always been hard in the swampy forests of Paliessie. Major towns were established only on the flood-free sandy ridges along the River Prypiać, which forms an east-west axis. Away from the rivers, which constitute the main transport corridors, the marshland forest has always been unsuitable for human settlement. Accordingly, the population density is necessarily low. In the forested areas, people's diets have tended, historically, to be based on milk, dairy products, forest fruits and mushrooms. After the nuclear disaster, however, such food products had some of the highest levels of harmful isotopes (Tykhyi, V. 1996). Yet, in the aftermath of the accident, people often made only temporary changes to their diets. They slowly became accustomed to the invisible danger and soon began to consume the products once again, doing so not least because of the economic difficulties.

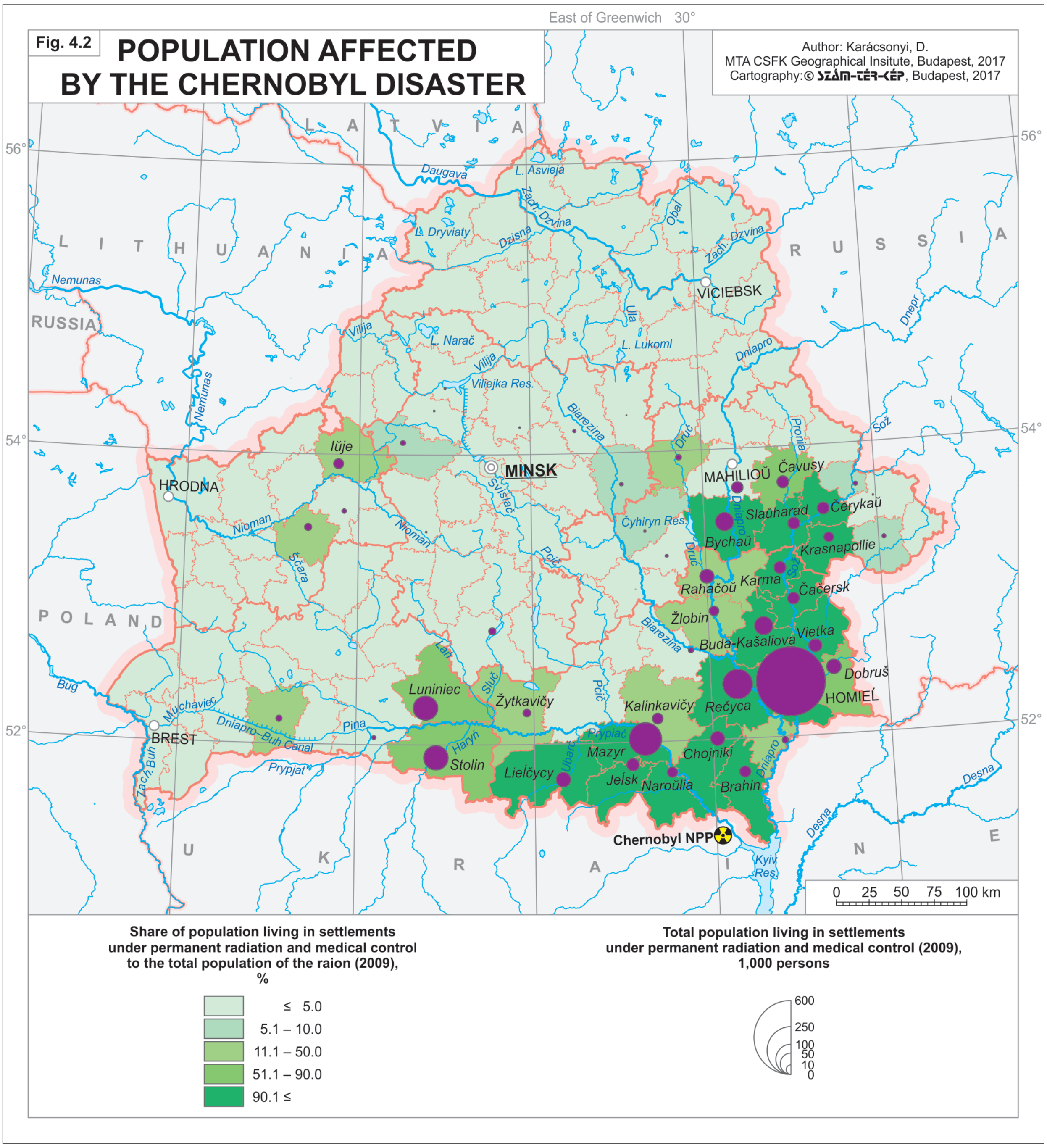


Fig. 4.2 POPULATION AFFECTED BY THE CHERNOBYL DISASTER

In the Soviet era, the industrialization of what had been a peripheral area was a priority goal. This resulted in the construction of the Mazyr oil refinery in the first half of 1970s. Further, Paliessie became a focus area for the Soviet nuclear power station construction programme, with the site of Chernobyl NPP at Prypjat' during the 1970s, and of Rivne NPP at Kuznetsovs'k (since 2016 renamed to Varash) in the 1980s in Soviet-Ukraine.

The **post-disaster evacuation and resettlement** process affected altogether 350,000 people (in the period until the 1990s) (Diercke Weltatlas 2008 96. p). However, the various sources give widely different numbers of people affected (492,000 – UN 2002; 326,000 – IAEA 2006). In Belarus, the population increased in the 1980s by 30,000 people each year, while in consequence of the Chernobyl disaster, 125,000 people were resettled in a country with a population of barely 10 million. In other

Table 4.1 **Distribution of number of settlements and their population by contamination zoning (2010)**

Name of radioactive pollution zone	Number of inhabited settlements/Number of inhabited urban settlements	Population/urban population (thousand people)
Immediate resettlement zone	18/0	3.1/ 0
Resettlement zone	480/5 (Vietka, Naroŭlia, Chojniki, Čačersk, Slaŭharad)	185.1/ 45.5
Inhabited zone of periodic radiation control	904/12 (Luniniec, Mikaševičy, Buda-Kašaliova, Homieĺ, Dobruš, Jeĺsk, Rečyca, Vasilievičy, Iŭje, Bychaŭ, Čavusy, Čerykaŭ)	1,120.4/ 690.4
Total	2,402/17	1,308.6/ 735.9

Source: Decree of the Council of Ministers of the Republic of Belarus of February 1, 2010 № 132 "On Approval of list of inhabited localities and places in the radio-active pollution zones and the admission the state of some decrees of the Council of Ministers of the Republic of Belarus".

words, the evacuation affected around 1.3% of the country's total population. The corresponding figure was 0.4% in Ukraine and 0.04% in Russia. In view of the large number of people who were resettled in the 1990s, the recipient regions – in particular the major towns and their environs – saw a relatively more favourable demographic trend. The consequences of the Chernobyl disaster are particularly apparent in the regional demographic processes of the 1990s, but even the evacuations of the 1980s left their mark on the evacuated territories (*Figures 5.1, 6.8*).

By the 2000s, the demographic shifts had subsided. Indeed, a degree of return migration is also detectable. The population of several small towns that lay in the contaminated areas but had been cleaned-up [Naroŭlia, Brahin and Chojniki (*Box 4.2*)] began to grow once more. In marginal areas that have undergone complex rehabilitation, people receive significant state assistance as well as apartments. In such small towns, the presence of young families with small children is striking. New houses and apartments are built with state funding. For this reason, in the contaminated areas, the population is becoming urbanized more rapidly than elsewhere. Indeed, these areas have become Belarus's "most rapidly urbanizing" regions.

Chernobyl did not rewrite the regional demographic structures or the population dynamics. The decline in population would be significant even without Chernobyl, which, however, did accelerate the process (Karácsonyi, D. 2012). Population density was low even before the disaster, and the evacuations merely accentuated this state of affairs. The disaster did, however, fundamentally alter the urbanisation processes and the network of villages. Smaller agrarian villages in remote areas disappeared in significant numbers, whereas small towns and minor urban centres became relatively more important.

In Belarus, state-run companies work the arable land in the contaminated areas, using modern mechanized technology. They are careful to carry out land assessments and avoid micro-depressions and furrows where there is a risk of the isotopes undergoing enrichment (hot spots). Rapeseed, fodder and cereal crops are grown. According to a report issued by the IAEA (2006), in the 15-year period after the disaster, large number of investments were made in Belarus in regions that bore the full brunt of the accident (such investments included schools, hospitals and social facilities).

Box 4.1 Lieĺčycy district – Potential tourist region eclipsed by Chernobyl?

Lieĺčycy district is located in the heart of Paliessie, just south of the River Prypiać and near the border between Belarus and Ukraine (*Figure 4.3*). The site of the Chernobyl disaster lies 70–80 km to the south-east. In the north-west section, the Prypiać National Park is to be found, with its centre at Liaskavičy (Pietrykaŭ district), a popular resort. Due to this specific geographic setting the district has a negative outward image. Still, it possesses favourable natural features that might be instrumental in fighting the “Chernobyl syndrome”.

There is just one urban settlement, the district seat of Lieĺčycy, with around 8,900 inhabitants. Otherwise, there are small villages and scattered settlements. The urbanization rate (34%) is well below the country’s average. Based on population density, Lieĺčycy district ranks the fourth sparsest in the country, after Brahin and Naroŭlia, two districts that were partially evacuated after the disaster, and the traditionally scarcely inhabited Rasony, which lies close to the border with Russia in the north. The population density in the area was very low even prior to the Chernobyl disaster; it was second only to Rasony district in the census of 1979 in Soviet Belarus. The population of the centre Lieĺčycy grew until 1999 and then began to fall, whereas other settlements have long exhibited dramatic population declines.

No major evacuation took place from the district after the Chernobyl disaster, as most of it lay in the zone of voluntary resettlement. Only two smaller villages, Kalinina and Baranava, disappeared. Owing to high radiation levels in these villages, the inhabitants had to be resettled. Subsequently, the buildings were demolished, the ruins buried, and the terrain afforested. Nevertheless, in 61 of the district’s 73 villages, radiation levels are significantly higher; 95% of the district’s inhabitants live in this area, where they are exposed to increased health risks. Most of the district has radiation values varying between 37 and 185 kBq/m^2 due to contamination with Cs-137. In other words, it lies for the most part in the permanent control zone. Over large tracts of the district, radiation values do not exceed those in Dachstein, Austria or in some Scandinavian localities that are visited by thousands of tourists annually. In the south-eastern part of the district – nearer Chernobyl – the radiation values vary significantly. (For instance, the values are as high as 555–1480 kBq/m^2 at the sites of the two evacuated villages mentioned above.) On the other hand, the accident did not affect the north-eastern portion of the district.

Lieĺčycy district is an extremely peripheral area; it is crossed by neither a major road nor a railroad. The nearest urban centre is Mazyr, which lies 80 km away. To the west, there are the Almansk marshes, which occupy an extensive area within the Prypiać valley. Consequently, there is no direct traffic connection to the Brest region. Access to other districts in the Homieĺ region is by way of two bridges over the River Prypiać, in Turaŭ and in Mazyr. The national border with Ukraine lies in the south; the only crossing at Hluškavicy leads to the Ukrainian Polissia, an even more deprived area.

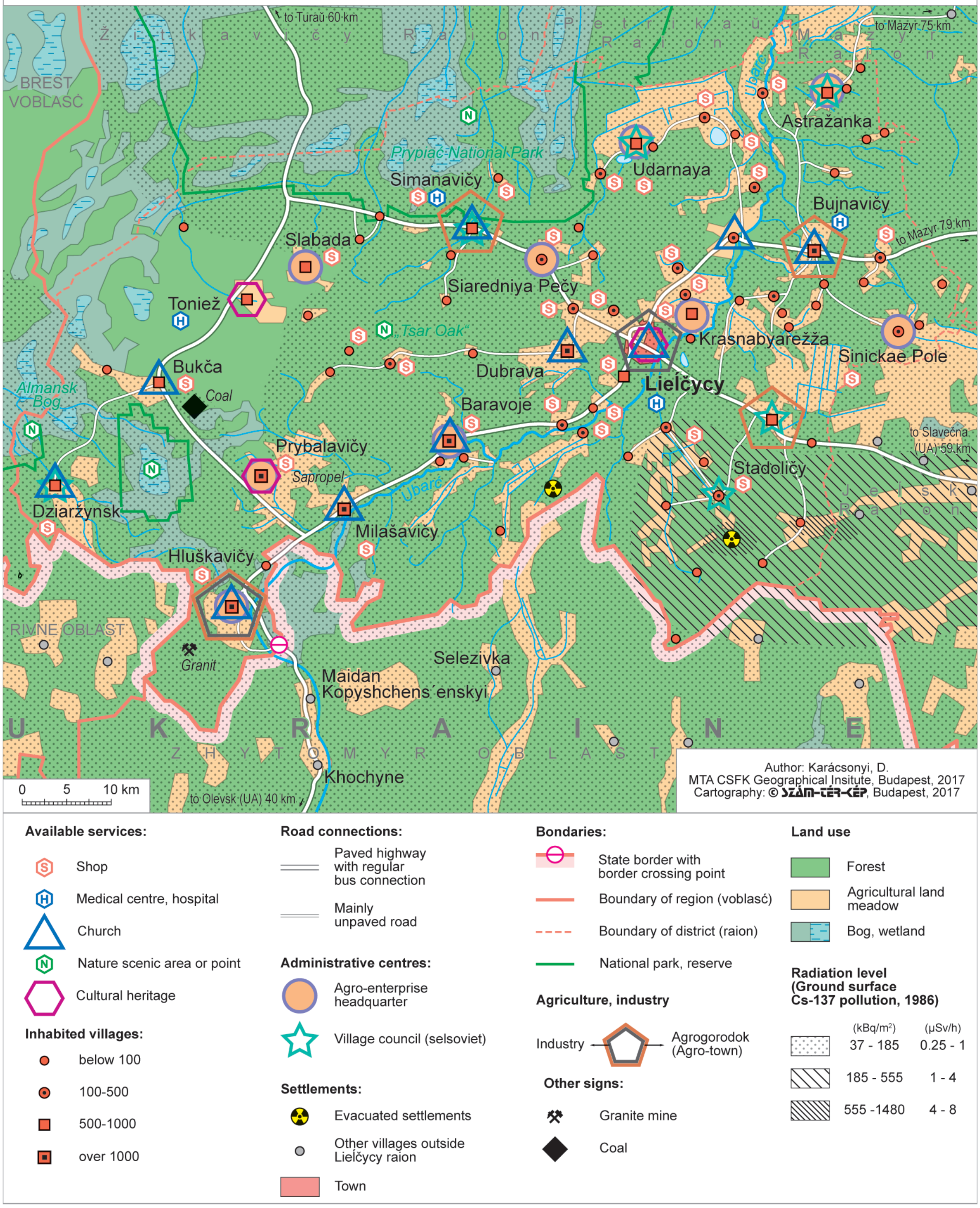
The resources of the district’s economy are also rather poor. Mineral resources include granite (Hluškavičy), sapropel (Prybalavičy), brown coal (Bukča) and peat. The most important raw material is wood and granite, however, in the lack of a rail connection they must be transported by road, which is more expensive.

Forests cover two-thirds of the territory, while the cultivated area extends over barely a tenth of the district. The share of arable land, mainly on sandy skeletal soils, is 6%. The higher radiation burden has exacerbated these unfavourable agroecological conditions. Agricultural produce is subject to radiation controls, where the strict threshold values are somewhat higher than the EU standards. However, food processing is also a major aspect of the economy. Forest produce that is very sensitive to radiation, such as mushrooms and berries (raspberry, blueberry, and cranberry), have considerable economic importance. A forest management company has a newly (2006) established cranberry plantation on 10 hectares near Lieĺčycy; the annual yield is 20 tonnes of fruit.

Arable land is used to produce rye, rape, buckwheat and fodder crops. Special types of buckwheat are planted to reduce soil radioactivity. Radioactive isotopes are mainly stored in the green parts of the plant and to a lesser extent in the seeds from which biodiesel is made. Accordingly, the green parts need to be separated and stored – a costly operation. Potatoes and vegetables are chiefly grown in household gardens, even though the soil has not been replaced

Fig. 4.3

LIEĽČYCY RAION



since the Chernobyl accident. Animal products have considerable importance for the economy, especially milk and butter production. The Kalinkavičy dairy plant maintains a subsidiary at Lieĺčycy, and the sector enjoyed generous state subsidies in 2007–2008. Altogether there are ten farming cooperatives in the district, and the largest agricultural machine and service station adds to the meagre industry of the district centre.

The service sector has been given a fresh impetus especially in the district seat, where bank branches, a post office, a hotel and several schools operate alongside a number of retail stores. In addition to business services, there are – similarly to elsewhere in the country – relatively well-developed social, cultural and health services. The town also hosts several libraries and cultural centres. Cultural and sport events – folk dance, vintage, harvest and patronal festivals – are held regularly, and performances by groups are organized at the house of culture. Rather than attract foreign tourists, such events meet the cultural and sport requirements of local people. In this sense, they differ from similar events in Western Europe.

The development of rural tourism has recently come to the fore; it is viewed as a possible remedy for the problems facing rural areas in Belarus. Several private ventures have been launched. At Svidnoe village, a large tourist centre was established using private capital. Foreign investors have not contributed, and to date few foreign tourists have come to the centre. Conditions are favourable for angling and hunting. Still, the area's negative image hinders progress in the tourism sector, and the training of experts in tourism has not even started yet.

Housing construction, mainly undertaken by the state, is concentrated in the district centre and four designated *agrogorodok*s (former villages developed into agrarian townships, see *Box 6.2*): for instance, in Stadoličy, Milašavicy. High-rise buildings for young people are under construction in the former, whereas in the latter, uniform detached houses (with small gardens) are typically being constructed. They are being targeted at younger people who have decided to move to a rural area. Even though employment opportunities are abundant, there are many vacant apartments and small houses. This calls into question the wisdom of central government funding for these projects.

In spite of the considerable distances, the public transport connections of the district and the frequency of services along the main routes are adequate and far better than the norm in Ukraine or Russia. Road surfaces are satisfactory; many minor streets are paved even in tiny villages. This protects against radiation, as such roads are not so dusty.

As a major part of the district lies in the permanent control zone, there is a relatively developed system of health services. Lieĺčycy has its own hospital. The inhabitants of the settlements affected by radiation receive a thorough medical examination every year. The residents of the relatively contaminated settlements receive medicines at subsidized prices or free of charge. Regional programmes are supported by the state and by the United Nations. Special medical-ecological courses are held in schools, educating young people about how to deal with the consequences of the accident and how to avoid health risks.

Camps for Chernobyl children are organized each year in ecologically clean areas, frequently at foreign invitation (in Germany, Great Britain, Ireland, Italy, Spain, and even in Canada). Children participating in such initiatives often live with local families, and many friendships have been established over the years. This has contributed to raising the children in a healthier environment and mitigating the negative image of the region in the media.

Despite the problems, the local population looks to the future with optimism. People feel a sense of social security in view of generous state support. On the other hand, they have become resigned to the consequences of the accident; they are either indifferent to or sceptical about the "invisible" radioactive contamination. This is clearly a psychological reaction: people are eager to learn what the future holds. They wish to put their troubles behind them, having grown tired of the problems of the last quarter of a century. (The text based on several interviews with the local authorities and people between 2007 and 2011.)

Painting in a bus stop near Chojniki town. The Chernobyl disaster radically changed the traditional Paliessian region, erasing dozens of small villages from the map. (Photo: Karácsonyi, D. 2010)

Traditional wooden blockhouse in a Polessian village – Lieĺčycy district. (Photo: Karácsonyi, D. 2015)

Box 4.2 Chojniki district – Evacuation waves and changing settlement patterns after Chernobyl

Chojniki district, which lies near the Chernobyl NPP on the Belarusian side of the border, is one of the most affected administrative districts in Belarus, both in terms of the extent of the contaminated areas and in terms of the share of the population affected (*Table 4.2*). At least half of the district lies in the evacuation zone, from which around 20,000 people were resettled in the first six to seven years after the disaster. Between 1979 and 1999, the district lost almost 60% of its population, and so, together with the neighbouring Brahin district, the effect of the accident in terms of population decline was greater here than anywhere else in Belarus. More than two-thirds of the rural population disappeared, and the network of villages – with the exception of villages in the environs of Chojniki and to the north of the town – was almost completely abandoned (*Figure 4.4*).

The Chernobyl Tragedy Museum in Chojniki has preserved, thanks to the efforts of local historians, a list of the names of evacuees as well as the exact population data for the various settlements in the district. The data, which cover the two decades after the disaster, were collected by a team of Japanese and Hungarian researchers in the summer of 2015. Subsequently, the entire database was digitalised. To our knowledge, no other district in Belarus disposes of such detailed population data and post-Chernobyl evacuation records.

The yearly changes in the rural population figures reflect the various waves of evacuation and resettlement. First, 8,000 people were required to leave their homes in 1986, being evacuated from the part of the district that lay in the evacuation zone. After independence, in the course of 1991–1992, they were followed by a further 8–10,000 evacuees from outside the evacuation zone. This resettlement wave coincided with the resettlement of people from highly contaminated settlements that lay near Vietka, Čačersk and Slaŭharad, at a greater distance from the evacuation zone designated in 1986.

Chojniki district's situation reflects the altered settlement patterns seen in similar districts after the evacuations. Whereas the smaller peripheral villages, which were inhabited mostly by older people, could be evacuated quickly and relatively cheaply, the evacuation of the larger villages and towns never took place. As a result, a substantial spatial concentration occurred, mainly to the benefit of urban settlements. This "caused" a rapid increase in the urbanization rate in these districts. Moreover, some of the people designated for resettlement did not leave the district but settled in the district centres, which were not subsequently evacuated. These district centres have been the exclusive target areas for recent population inflows, which are promoted in part by state subsidies.

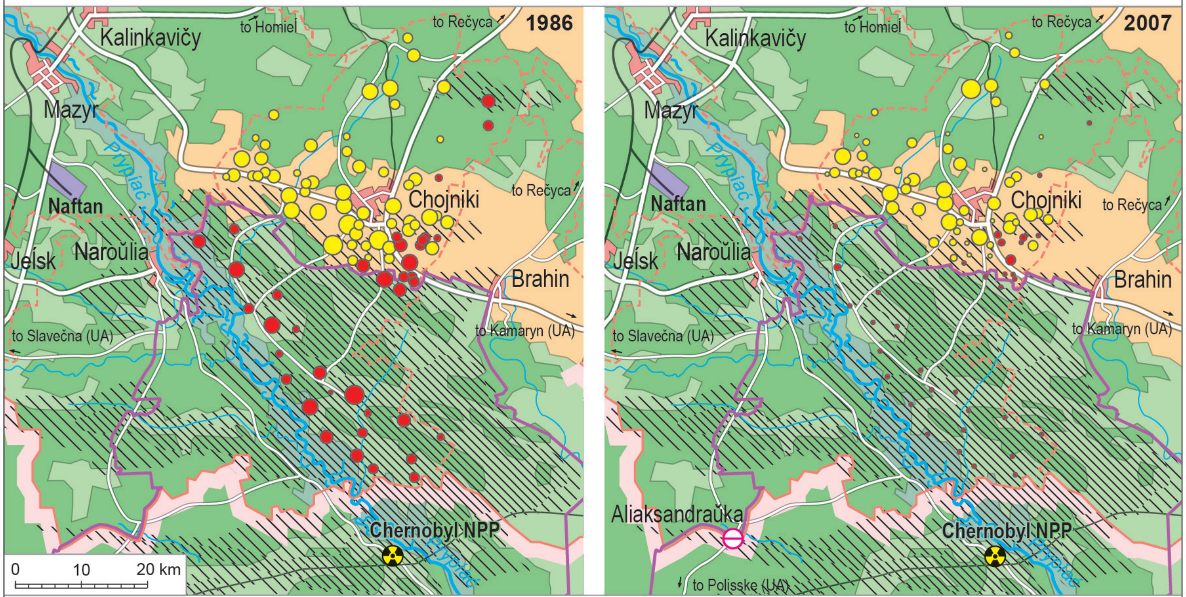
Table 4.2 ***Change of population of raions most affected by the Chernobyl disaster (1979–2000)***

Raion	Country	Total population loss %	Total population loss persons	Urban population loss %	Rural population loss %	Ratio of contaminated area by Cs-137 % over 0.25, 1 and 4 μSv/h (1986)
Polisske	Ukraine	–80	–29,748	–100	–69	70, 51, 27
Narodichi	Ukraine	–64	–20,554	–58	–66	96, 28, 23
Brahin	Belarus	–61	–27,365	–26	–69	100, 56, 30
Chojniki	Belarus	–57	–24,476	–1	–68	100, 79, 57*
Vetka	Belarus	–52	–22,812	–11	–62	100, 97, 63
Naroŭlja	Belarus	–48	–16,449	–13	–75	100, 94, 47
Ivankiv	Ukraine	–46	–50,251	–17	–63	100, 28, 19
Novozubkov	Russia	–32	–26,327	–16	–56	100, 100, 76

*31% of the total area of Chojniki raion was over 8 μSv/h in 1986.
Source: Regional statistical yearbooks of Belarus, Ukraine and Russia and author's own calculation.

Fig. 4.4

CHOJNIKI RAION



Evacuation after Chernobyl
- no evacuation
- evacuation

Road connections:
- Main road
- Other road
- Railway

Bordes:
- State border with border crossing point
- Boundary of region (voblasć)
- Boundary of district (raion)
- Chernobyl evacuation zone

Land use
- Forest
- Agricultural land
- Bog, wetland

Radiation level (Ground surface Cs-137 pollution, 1986)

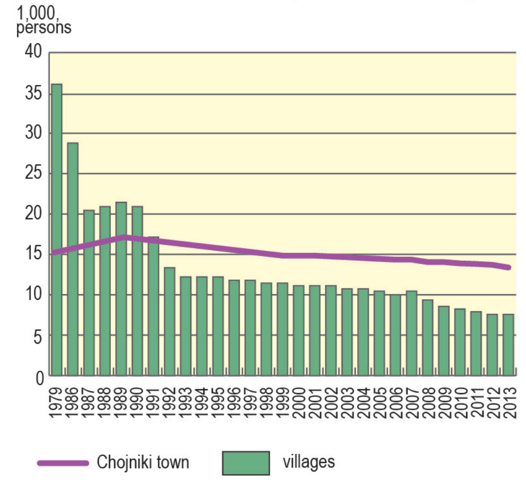
(kBq/m²)	(µSv/h)
555 - 1480	4 - 8
over 1480	over 8

Population size of villages of Chojniki Raion
- empty
- 1-50
- 51-200
- 201-500
- 501-1000
- over 1000

Built-up area
- Urban settlement
- Industrial area

Author: Karácsonyi, D., MTA CSFK, Geographical Institute, Budapest; Hanaoka, K. Ritsumeikan University, Kyoto 2017
Cartography: Karácsonyi, D., Kovály, K. MTA CSFK, Geographical Institute,

URBAN AND RURAL POPULATION (1979–2013)



RURAL POPULATION CHANGE (1986–2007)