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Sallaku F., Shallari S.

in

Camarda D. (ed.), Grassini L. (ed.).
Local resources and global trades: Environments and agriculture in the Mediterranean region

Bari : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 57

2003
pages 55-62

ENVIRONMENTAL CLEAN-UP AND SUSTAINABLE DEVELOPMENT OF CONTAMINATED AREAS AROUND THE METALLURGICAL COMBINE OF ELBASANI, ALBANIA

Fatbardh Sallaku*, Seit Shallari**
*Agro-Environmental Department, Agricultural University of Tirana, Albania
**General Secretary of the Ministry of Agriculture and Food, Albania

ABSTRACT

Farmers in Albania, as elsewhere, are heavily dependent upon natural resources for their livelihood. The basis of this dependence is the soil upon which crops are produced and livestock are raised. Natural water systems (groundwater and surface water) are managed through irrigation systems for their input to crop production. Forests provide the farmer with materials for building as well as with fuel for heating and cooking. Providing that all of these resources are utilized in a sustainable way, the resource base can continue to provide the farmer with a sound basis for sustainable production and income. However, the farmer and others do not manage the resources on a sustainable basis. Soil erosion is a serious issue in Albania and thousands of tons of productive topsoil are lost annually. The problem is related to inappropriate forest harvesting that has led to serious forest degradation, as well as poor soil management practices and overgrazing of pastures. Effective drainage systems are required to ensure minimal salinization, a process that results in loss of productive land. Albania faces many of the same environmental issues with which other countries in Eastern Europe are being confronted. Both air and water pollution are serious issues as a result of the lack of facilities and controls. Industrial effluents contribute to surface water contamination and industrial emissions contribute significantly to poor localized air quality and acidification of surface waters. Contaminated soil, water and air from industrial activities, soil erosion, deforestation, overgrazing, illegal logging and clearcutting, lack of effective human and solid waste disposal, and the visual evidence of a lack of sound resource planning and resource allocation are perhaps the most serious environmental problems in Albania today. Overall, roughly 85% of the land resource stresses are of anthropogenic nature, which implies that the trend for the future may be directed either towards aggravation of the situation or improvement. Elbasani district is the major agricultural area of the country, providing produce to both the Elbasan area and Tirana City. The World Bank declared that the area located around the metallurgical complex is one of Albania's most important “hot spots”. The region is endowed with good soils and climate. However, because of the industrial activity of the metallurgical complex, the soils around it are highly contaminated by heavy metals such as cadmium, nickel, chromium, lead, and copper. Consuming vegetables and other crops grown in this area presents a serious health risk to those eating these products. Immediate action is required to ameliorate the situation generally since all the natural resources (soil, water, air) have been contaminated. Sustainable development of this area, based upon our long-term strategy, will increase the incomes of the associated communities, increase their property values, and improve the health situation. To achieve these goals, we conducted a field research/demonstration program illustrating appropriate cropping systems, demonstrating to farmers the potential of particular plants to extract heavy metals from contaminated soils, and we organized an educational program for both the local farmers and local authorities within the study zone.

1. INTRODUCTION

The World Bank declared that the area located around the metallurgical complex of Elbasan is one of Albania's most important “hot spots”. This is the biggest metallurgical complex in Albania. It was built by the Chinese in 1976 and is currently operated by a Turkish firm. It has a treatment capacity of 800 thousand tons per year of iron-nickel ores. This metallurgical operation, still using the original technology installed in 1976, plays a central role in the industrial base of the Elbasan area. Not surprisingly, its impacts on the environment are extreme. According to the World Bank, this metallurgical combine released in 1991 an estimated 44.8 tons of toxic dust/year. The contaminants emitted from this complex have, perhaps, the greatest effect on the Shkubini River, the main watershed for the region. As a result, the Shkubini is one of the most polluted rivers in Albania. Nevertheless, its waters are used to irrigate agricultural crops downstream.

The pollution emitted from this complex has caused many problems to the microenvironment and has had adverse effects on the health of various categories of peoples, especially pregnant and mothers in breast-feeding period. Problems of professional diseases are very evident in this area. They have been caused by the presence of toxic gases, vapors, and dust. The World Bank observed in 1993 that flora modifications are generally present on soils contaminated by industrial and mine discharges. Consequently, its impact on the agroenvironment cannot be dismissed, not least in Albania where laws preventing such discharges, if existing at all, are not enforced.

According to statistical data, the Elbasan district is one of the major agricultural areas of the country, providing produce to both the Elbasan and Tirana Cities. The region is endowed with good soils and climate. However, because of the industrial activity of the metallurgical complex, the soils around it are contaminated by heavy metals such as cadmium, nickel, chromium, lead, and copper. Consuming vegetables and other crops grown in this area presents a serious health risk to those eating these products. Our scientific data shows that the level of cadmium is up to 3 mg/kg soil, nickel up to 695 mg /kg soil, chromium up to 630 mg/ kg soil, lead up to 120 mg /kg soil, and copper up to 244 mg /100 kg soil. These soils are, therefore, highly contaminated and require attention. The adverse effects on the human population include the following issues:
(i) loss of high quality farmland and private and public property values, pollution of soil and groundwater, (ii) enhanced demand for clean water, contamination of urban areas, and increased public health problems, and (iii) low grazing quality and reduced crop yields and livestock production. Based on that situation, immediate action is required to ameliorate the situation generally since all the natural resources (soil, water, and air) have been contaminated. Sustainable development of this area, based upon our long-term strategy, will increase the incomes of the associated communities, increase their property values, and improve the health situation. This paper assesses the impact of the management and use of natural resources on sustainable way for the farmer and his production systems.

2. DESCRIPTION OF THE AREA

The study was conducted in the Elbasani district where the area located around the metallurgical complex according to the World Bank is declared as one of Albania's most important “hot spots”. In this district there is the biggest metallurgical complex operating in Albania. It was built by the Chinese in 1976 and is currently operated by a Turkish firm. It has a treatment capacity of 800 thousand tons per year of iron-nickel ores. This metallurgical operation, still using the original technology installed in 1976, plays a central role in the industrial base of the Elbasan area.

The Elbasani district is situated in the central area of Albania. The district is 3292 square kilometers and has a varied topography with more than 70% of the area being comprised of hills and mountains, the latter reaching altitudes exceeding 1411 meters. Climate changes are significant due to the broken mountainous relief, characterized by an average precipitation between 900 to 1300 mm and altitude between 70 to 128 m above sea level. The annual average of rainfall is 1170 mm but in mountain areas it may reach 2000 mm. The amount of agricultural land per capita in the Elbasani region is about 0.22 hectares and the average farm size is about 1-1.3 ha. Loam soils dominate the Elbasani area, comprising of about 45% of the district's soil cover. Clay and sandy soils make up approximately 35% and 20% respectively. The soils in the mountainous regions of the district are very shallow and their vulnerability to erosion, due to their shallowness and topography, is high. These soils represent in total about 55% of the total arable area in the district. Production systems remain primitive, yields remain low, many farms are too small and fragmented to be viable, physical infrastructure is poor, and private sector activity has yet to fully fill the vacuum left by defunct state processing and marketing agencies. The family farms are mixed operations of cereals, fruits, vegetables, and livestock. Only a limited number of farms, mainly those located close to urban areas, practice a more intensive form of agriculture that allows them to produce for the market. During the transition the support structures for agriculture disintegrated. The already poorly functioning irrigation system was made completely ineffective in the early 1990s. the Elbasani region faces a number of serious environmental problems, some of which are directly related to agricultural activities both current and in the past.

Probably the most serious environmental problem relative to agriculture is the heavy loss of topsoil and nutrients due to poor soil management and loss of natural vegetation, particularly on moderate to steep slopes. In the past the use of chemical inputs was high, and a return to former levels of application could be probable if improved production and marketing opportunities are introduced. This could lead to nutrient overloading of natural waterbodies and contamination of both soil and water, particularly if large inputs of pesticides are used.

3. RATIONALE AND OBJECTIVES

The overall objective of this study was to create and implement a viable strategy for the recovery of contaminated areas in the Elbasan Prefecture and to provide a framework for long-term, sustainable development of similar areas throughout Albania, and to improve crop productivity under sustainable natural resource management. The scientific approach used in this study emphasized participatory methods to ensure integration of indigenous knowledge and local experiences, in planning and implementation of agricultural technology development. The project has coordinated the involvement of relevant local, regional, and national authorities, university students, and local farmers to plan and implement the project's strategies and activities. The proposed project is expected to have a direct and positive impact on the productivity of these areas, on the reduction of contamination index and protection of these areas in study zone, which are critical for the agricultural production in this region. The rational use of these areas is also expected to halt the current degradation process that is most threatening to biodiversity and sustainability of ecosystems for these areas. Natural resource management issues were also incorporated by implementing field activities through a community-based approach that focused on micro-watershed and householders as basic implementation units.

4. METHODOLOGY

The premise of this study was that sustainable development depends on a good match between land quality and land use. Land degradation and unsustainable land use practices result when there is a mismatch. During period 1998-2000 we conducted a study in two Communes around the metallurgical combine of Elbasan, which are the major agricultural areas of this district, providing produce for the majority of Elbasani and Tirana City. The region is endowed with good soils and good farming systems. However, because of the industrial activity of the metallurgical complex, the soils around it are contaminated by heavy metals such as cadmium, nickel, chromium, lead, and copper. Consuming vegetables and other crops grown in this area presents a serious health risk to those eating these products. For that reason, two communes were selected to typify the overall study area while allowing researchers to define effects of localized features. The criteria for selecting the areas to be studied were that they should be representative of the soils and farming systems of the region.

During the initial phase of the survey, we identified the required personnel, facilities, resources, and information already available on the ground to assist in project implementation. The survey data were collected to evaluate any changes over the last ten years; to assess the attitudes and knowledge of farmers with respect to soil protection; and to consider the need for further guidance to alleviate any problems found. We provided a considerable amount of data on the soil, water, and air contamination. This data was derived from previous our studies in the region and was used as a baseline for the current project. Land area under selected communes consisted of 3 to 5 villages and average about 900 ha supporting about 650 family farms. The first phase of the study focused on characterization of the land use systems at the household and community levels using a battery of participatory methods. This baseline information was used to describe the farming systems, the risk of soil contamination in the food chain system, the risk of vegetable cultivation in these zones for fresh production, etc. We also described the production constraints at the farm level and micro-watershed by establishing the current levels of the natural resources base, such as mean farm size and distribution, and available household labor. The farmers' strategies to manage these households' resources and exploit common pool resources were also established. Individual farmer interviews were used to identify different farmer categories in each commune, such as small group discussions, resource-mapping, etc. The team surveyed farmers and participated in group discussions with them during the project implementation. The objective was to assess the problems the local community faces, in their own words, in relation to farming and food production in the study zone. The team developed 200 questionnaires. A random sampling of farmers, organized according to farm size, farming system, soil characteristics, and irrigation capability, was delineated. The most extensive interviews and discussions took place with farmers who had very good farming systems and had faced a variety of problems. We recorded the farmers' views on soil management and soil protection issues on their farms. The farmers explained how they viewed problems on their farms and rated them according to the estimated seriousness of each. The second phase consisted of an extensive participatory on-farm trail, to evaluate, identify, develop, and promote the practices that were most productive and more easily adapted from the local community. These technologies aimed to increase soil organic matter content, prevent formation of soil crust and compacted layers through minimum tillage, and improve soil structure and water holding capacity. The proposed project has offered solutions for long-term sustainable development, using appropriate technologies stressing to make more and better use of those crops able to grow in contaminated environments, use crop residues more efficiently and introduce better crop rotations and promote relay cropping and improve pasture management. In the project the experience and results of two ongoing field experiments in the Elbasan area have been incorporated. These field experiments (since 1998) have tested the recovery of contaminated arable land through the use of hyperacumulator plants (such as *Alyssum murale*). Metal hyperaccumulator plants are highly specialized species with the capacity to concentrate metals such as Zn, Ni, Cd and Pb to levels far in excess of normal physiological concentrations, in their upper plant parts.

The use of such hyperaccumulator plants to extract metals from surface-contaminated land could represent a low technology, natural means of in situ soil remediation. According to our scientific results *Alyssum* hyperaccumulator species take-up the nickel from soil at a higher level (2% DM). The analyses focus on the impact of land management on sustainable land use of farmers taking productivity, incomes, etc. During the project we presented data illustrating the effect of low soil fertility and metal toxicity limitations to plant growth. During these meetings, in conjunction with the local agricultural directorate officials, we suggested using improved agronomic practices. We suggested with techniques such as: planting dates, fertilizer and mulching requirements, tillage operations, crop suitability, and optimal land use options. We discussed alternative farming practices with farmers based upon their specific operations. They were interested in what they could do to alleviate the negative health and agronomic effects of the soil contamination. As an integral component of the design and development process, aimed at incorporation of local knowledge in the field protocols, these groups were used in planing, implementation and evaluation. With our assistance they have organized, cultivated, and monitored field research and demonstration plots. We provided hyperaccumulator plant seeds for these field research/demonstration plots and then assessed the plants' potential for metal uptake and soil quality improvement. These field research/ demonstration programs have illustrated the appropriate cropping systems. We also demonstrated to farmers the potential of particular plants to extract heavy metals from contaminated soils by showing the results of the plots cultivated, and the experience and results obtained from two ongoing field experiments in the Elbasan area, as well. The menu of options presented to farmers and included as treatments in the on-farm trail consisted of agricultural technologies which have been demonstrated to improve soil fertility and hence increase crop production under pollution conditions, and are currently under on-farm review. They consisted of farming systems based on crops that are capable of growing in polluted soils and characterized by a low “transfer factor” such as forages (alfalfa, clover), wheat, maize, etc.

5. RESULTS AND DISCUSSION

Group discussion and individual contacts integrated each other in terms of overall information collected and provided the possibility for farmers, scientists, and agricultural directorate staff to confer on the description of land use system, diagnosis of production constraints and identification of potential remediation technologies in the polluted areas.

Table 1. Farming Systems Description of the Study Zone.

	Shrigjan	Bradashesh	Jagodine	Bujqez	Kuqan
Total area (ha)	720	1100	560	460	420
Project area (ha)	150	150	120	100	130
Total Households (No)	600	1300	490	480	360
Participating (household)	55	75	25	20	20
Mean farm size (ha)	1.2	0.8	1.1	0.9	1.15
% farmers aware of remediation techniques	22	9	15	20	25
% farmers ready to apply remediation techniques	85	75	85	80	90
% incorporate residue	80	50	70	65	75
Main crops	Vegetables Maize Wheat Forages	Vegetables Maize Wheat Forages	Vegetables Maize Whet Forages	Vegetables Maize Wheat Forages	Vegetables Maize Wheat Forages
Minor Crops	Tobacco Potatoes Fruits	Forages Potatoes Fruits	Tobacco Potatoes Fruits	Beans Potatoes Fruits	Beans Potatoes Fruits
Main Soils	Sandy-loam	Sandy-loam	Sandy-loam	Sandy-clay	Sandy-loam

The participation of farmers in all phases of the project gave them a high sense of ownership. Two major points emerged from our survey of the Commune's rural areas: we must always look at the problem of soil contamination from the farmers' preception and his set of limitations and we must then enable them to see soil contamination as their problem, subject to solutions to which they must contribute their input. In addition to being technically effective, soil contamination control measures must fit the economic, social and psychological framework of farmers.

Table 2. Cropping pattern (ha) in study zone for year 1998.

NR		Shrigjan	Bradashesh	Jagodine	Bujqez	Kuqan
1	Vegetables	330	650	320	290	250
1.1	Spinach	30	50	20	10	20
1.2	Lettuce	80	160	110	60	50
1.3	Tomatoes	120	220	90	120	100
1.4	Carrot	50	70	40	30	20
1.5	Radish	20	30	10	20	10
1.6	Leek	30	120	50	50	50
2	Maize	85	90	60	45	50
3	Wheat	80	110	70	60	40
4	Alfalfa	90	80	50	20	30
5	Clover	30	40	10	10	10
6	Potato	20	30	10	5	10
7	Beans	20	10	10	10	5
8	Oats	10	20	5	5	5
9	Fruits	40	30	15	10	15
10	Uncultivated land	15	40	10	5	5
	Total	720	1100	560	460	420

We stressed these points in our overall management of the project and when communicating the project's strategies to farmers, local officials, and national leaders. In general, farmers with smaller farms were more interested in using remediation practices and cultivation of different crops able to grow in those sites.

Table 3. Cropping pattern (ha) in study zone for year 2000.

NR		Shrigjan	Bradashesh	Jagodine	Bujqez	Kuqan
1	Vegetables	250	460	230	210	180
1.1	Spinach	20	60	20	10	10
1.2	Lettuce	30	80	40	40	30
1.3	Tomatoes	120	150	90	80	90
1.4	Carrot	40	60	30	30	10
1.5	Radish	10	20	10	10	10
1.6	Leek	30	90	40	40	30
2	Maize	90	130	90	70	60
3	Wheat	100	140	100	90	85
4	Alfalfa	130	120	70	40	45
5	Clover	40	80	20	15	10
6	Potato	20	40	10	5	5
7	Beans	20	20	10	10	5
8	Oats	10	30	5	5	5
9	Fruits	45	50	15	10	20
10	Alyssum Murale	2	1	3	3	1
11	Uncultivated land	13	26	7	2	4
	Total	720	1100	560	460	420

Cropping in polluted soils and erodible slopes, was more prevalent in villages located close to the city. Maize, wheat, vegetables and forages were grown extensively in all villages. There is a tendency to reduction of the surface cultivated with vegetables, mainly those consumed as fresh production, and the increase of the surface cultivated with crops that have a low “transfer factor” of heavy metals in the food-chain system.

The data presented in tables 2 and 3 give a clear view of the cropping patterns in the study zones. Examination of the initial selection of remediation technologies and agricultural practices used in the on-farm trail, showed farmers were more interested in crops that could provide incomes as well as improve soil fertility and could be safe for consumption. As a result of our education and training program in the study zone, the farmers have started to change their cropping patterns and to grow hyperacumulator plants such as Alyssum Murale in abandoned soils, which take-up the nickel from soil at a higher level, and reduce soil erosion.

For example, out of the 195 farmers involved in this study, 56% choose Alfalfa as their first choice to cultivate on their farms. Results from individual farmer assessment indicated that there were no discernible differences in the performance of remediation technologies. Mean maize yield was about 5.8 tons per hectare, wheat 3.5 tons per hectare, alfalfa 40 tons, showing a significant increase of yield in the second year of our project.

Table 4. Estimated mean crops yields (kv/ha) comparing different technologies for the study zone during the period (1998-2000).

	Shirgjan		Bradashesh		Jogodine		Bujqëz		Kuqan	
	1998	2000	1998	2000	1998	2000	1998	2000	1998	2000
Wheat	36	42	30	35	35	40	32	34	36	38
Maize	56	60	50	52	55	65	48	56	56	62
Bean	15	18	14	15	17	21	16	18	15	19
Potato	110	115	90	105	110	130	95	115	90	100
Carrot	150	170	140	150	150	180	160	180	170	175
Tomato	300	320	290	295	310	350	310	340	315	330
Forage	400	410	360	380	400	450	390	410	380	390

Table 5. The number and Livestock composition during the period 1998-2000.

	Shirgjan		Bradashesh		Jogodine		Bujqëz		Kuqan	
	1998	2000	1998	2000	1998	2000	1998	2000	1998	2000
Cows	480	650	950	1200	520	580	600	720	420	460
Oxen	20	15	40	60	10	12	20	25	10	15
Calves<1year	360	480	560	620	460	510	420	610	280	310
Calves>1year	280	350	380	390	350	360	320	420	210	290
Sheep	120	100	250	240	150	140	50	70	80	85
Goat	-	-	25	40	-	-	-	-	-	-
Poultry	3000	4500	8500	9200	4500	4800	5000	5600	4500	5200

The data presented in Table 5 show the tendency of the livestock structure and production in the study zone during 1998-2000. Livestock is one of the agriculture activities lots of farms are involved in. Although on-farms incomes' generated from livestock are not comparable with those generated from cash crop cultivation, livestock still remains the main source of income for those farms that do not have other choices due to their specific conditions as a result of soil contamination that makes the cultivation of vegetables and other cash crop cultivation impossible. The table presented above (Table 5), illustrates the trends of the livestock sector during the years 1998-2000. As can seen sharp increases were recorded during 1998-2000 period, when each farm tried to position itself within a changing economic environment by adopting risk-adverse strategies. This trend is followed by an increased area cultivated with forages, such as alfalfa, clover, and other legumes. These crops are able to grow and adapt very well to polluted soils and the “transfer factors” are low compared to vegetables and other crops. This farm structure creates the possibility to reduce the adverse effects on the human population and an increase in quality farmland and private and public property values. Moreover, the use of such farm structure will decrease the risk of soil and groundwater pollution, the contamination of urban areas, and public health problems. There was a notable variation in farmer evaluation criteria of different technologies. Highlights from group discussion indicated that criteria used to assess the pros and cons of improving soil quality through different remediation measures depend on the farmers' priorities, objectives and farm resources. The general consensus from group discussions was that the cultivation of forages, maize and wheat instead of vegetables such as lettuce, spinach, etc, can provide the same income and more importantly will decrease the health risk. Field observation and group discussions evidenced an increase in the awareness of resource management concerns in the study zone. For example, the cultivation of Alyssum murale, and other crops able to grow in contaminated soils, increased even in sites where they were not cultivated traditionally before. A very important result of this project was the convincing of farmers and local authorities that they can limit soil contamination. Through cultivation of and tours to demonstration plots, we highlighted different plant species that limit heavy metal contamination. These field trips presented the farmers and local officials with persuasive information about potential solutions to the problems they faced. We also conveyed in our numerous meetings with farmers and local officials that the primary source of soil and water pollution is man and his activities. We always offered modern, environmentally sound alternatives supported, in turn, by scientific data illustrating the viability of such methods. An extensive use of fito-remediation technologies needs well established technical support in the following areas:

- support services to farmers to facilitate provision of initial technologies, seeds, and other inputs, training and on-farm demonstration;
- an incentive framework for farmers, addressing of major constraints associated with irrigation and drainage measures.
- production and delivery of the effective training materials incorporating conservation as a part of good farming practices in order to transfer skills and simple methods to the end-users
- sensitize farmers and local authorities to environmental degradation as a yield loss and quality-of-life issue

5. CONCLUSION

The proposed development model, which combines the fito-remediation technologies with technical agricultural measures in areas with polluted soils, is fostered for areas with an agro-pastoral tradition, but which are ecologically unfit for intensive farming systems. The emphasis of the paper is therefore on the effectiveness and utility of the methodological approach. The major benefits would be the increase of the lifespan of main resources due to reduced soil contamination. Reduction of rural migration to the towns will be an added, long-term benefit to the local communities, municipalities, and farmers. We expect economic and environmental migration to decrease due to increased fertility of soils and general improvement in natural resources as a whole. We also, expect to inform local and national legislators about the results of this project and request that they create legislation supporting natural resource conservation and environmental clean-up. Our philosophy is that this initial pilot project is but the start of a long-term agroenvironmental rehabilitation scheme. We believe it should begin with this pilot study and expand slowly as the ideas, concepts, and strategies are refined at increasingly larger levels of participation.

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