Global Water Partnership
Central and Eastern Europe

Integrated Drought Management Programme
in Central and Eastern Europe

Assessment of drought impact on forests
*(act. 5.2)*

# OUTPUT 3 / Milestone 4:
# Adaptation measures for the forests to mitigate negative effects of the drought

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| Name of the milestone: | **Milestone 4:** Development and approval of methodology for adaptation measures of the forests over vulnerability zones of the years of 2050 and 2070 and establishment of programme of measures for forest adaptation measures and mitigation the negative effect of drought on them<br>**OUTPUT 3:** Adaptation measures for the forests to mitigate negative effects of the drought |
| WP: | **WP5** |
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## ACRONYMS

| | |
|---|---|
| AR5 | Fifth Assessment Report |
| CEE | Central and Eastern Europe |
| EC | European Commission |
| EU | European Union |
| GWP | Global Water Partnership |
| GWP CEE | Global Water Partnership for Central and |
| IDMP | Integrated Drought Management |
| IPCC | Intergovernmental Panel on Climate |
| RBMPs | River Basin Management Plans |
| RCPs | United Kingdom |
| UK | Representative Concentration Pathways |
| *Bulgaria* | |
| EFA | Executive Forest Agency |
| FPS | Forest Protection Station |
| FRI-BAS | Forest Research Institute within Bulgarian Academy of Sciences |
| FSCS | Forest Seed Control Station |
| IBER – BAS | Institute for Buodiversity and Ecosystem Research within BAS |
| MAF | Ministry of Agriculture and Food |
| MEET | Ministries of Economic, Energetics and Tourism |
| MEW | Ministry of Environment and Water |
| MHC | Ministry of Health Care |
| MI | Ministry of Interior |
| MLSP | Ministry of Labor and Social Policy |
| MRDPW | Ministry of Regional Development and Public Works |
| NIMH – BAS | National Institute for Meteorology and Hydrology within BAS |
| RBD | River Basin Directorate |
| RFD | Regional Forest Directorate |
| SFE/SHE | State Forest/Hunting Enterprise |
| UF | University of Forestry |
| *Slovenia* | |
| ACPDR | Administration of the Republic of Slovenia for Civil Protection and Disaster Relief |
| EAS | Environmental Agency of the Republic of Slovenia |
| FE | Forest enterprises |
| IRSNC | Institute of the Republic of Slovenia for Nature Conservation |
| MAFF | Ministry of Agriculture, Forestry and Food |
| MESP | Ministry of Environment and Spatial Planning |
| RBMP | River basin management plan |

| | |
|---|---|
| SFI | Slovenian Forestry Institute |
| SFS | Slovenian Forestry Service |
| UL | University of Ljubljana, Biotechnical faculty, Department for forestry and renewable forest resources |
| *Lithuania* | |
| DGSF | Directorate general of the state forests at the Ministry of Environment of the Republic of Lithuania |
| FE | Forest Enterprises |
| LFRI | Lithuanian Forest Research Institute of the Lithuanian Research Centre for Agriculture and Forestry |
| LIA | Lithuanian Institute of Agriculture of the Lithuanian Research Centre for Agriculture and Forestry |
| LHS | Lithuanian Hydrometeorological Service under the Ministry of Environment of the Republic of Lithuania |
| MA | Ministry of Agriculture of the Republic of Lithuania |
| MES | Ministry of Education and Science of the Republic of Lithuania |
| MF | Ministry of Finance of the Republic of Lithuania |
| ME | Ministry of Environment of the Republic of Lithuania |
| PGB | Plant Gene Bank |
| SFS | State Forest Service |
| NPA | National Paying Agency under the Ministry of Agriculture |
| *Ukraine* | |
| FPE | Forest Protection Enterprises |
| FSCS | Forest Seed Control Station |
| MAPF | Ministry of Agrarian Policy and Food |
| MEDT | Ministry of Economic Development and Trade |
| MENR | Ministry of Ecology and Natural Resources of Ukraine |
| MHC | Ministry of Health Care |
| MLSP | Ministry of Labour and Social Policy |
| MRDCHU | Ministry of Regional Development, Construction and Housing Utilities |
| RBD | River Basin Directorate |
| RFHA | Regional Forest and Hunting Administration |
| SAFR | State Agency of Forest Recourses |
| SAWR | State Agency of Water Resources |
| SSE | State service of emergencies |
| SFE/SHE | State Forest/Hunting Enterprise |
| UF | University of Forestry |
| UHMI | Ukrainian Hydrometeorology Institute |
| URIFFM | Ukrainian Research Institute of Forestry and Forest Melioration |

## 1. Introduction

Drought is no longer merely a future scenario - it is already in progress. Examples include increasingly frequent heat waves, melting glaciers and permafrost, the earlier start of the growing season, etc. All of these are indications of our changing climate. Adaptation to climate change must start now (EC. 2013).

Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (EC. 2013). There are different ways in which adaptation can be framed. As of January 2013, 15 EU Member States have adopted a national adaptation strategy to climate change: Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Lithuania, Malta, the Netherlands, Portugal, Spain, Sweden and the UK. Although there is no "one-size-fits-all" framework for adaptation in place, certain aspects of good adaptation are common. One of limiting factors for successful adaptation is a further need for climate change risks and vulnerability assessments (EC. 2013).

The objective of Milestone 4 is to establish the adaptation measures, and activities directed at enhancing capacity to adapt (building adaptive capacity) and mitigate the drougt impact on forests on the base of forest vulnerability zones in Bulgaria, Slovenia, Lithuania and Ukraine (pilot area), defined in Milestone 3 according to projections of IPCC AR5 and WorldClim data set.

## 2. National forest adaptation measures

Bulgaria, Slovenia, Lithuania and Ukraine are at different stages in preparing, developing and implementing of national adaptation strategy to climate change in different sectors as well as for forest sector.

### *Bulgaria*

Some forest adaptation measures have been undertaken in National strategy for forest sector development in Republic of Bulgaria for the period 2013-2020 (Republic of Bulgaria. 2013). Most of the different activities in Chapter „Enhance the resilience and adaptability of forest ecosystems to climate change" of the forest strategy are based on „Programme of measures for adaptation of the forests in the Republic of Bulgaria and mitigation the negative effect of climate change on them". This Programme has been establised under the frame of FUTUREforest project, INTERREG IV C Programme of EU (Raev et al. 2011). The Programme of measures was officially adopted by the Ministry of Agriculture and Foods on May 3, 2011 (Executive Forestry Agency. http://www.iag.bg/docs/lang/1/cat/5/index) .

### *Slovenia*

The National Climate Strategy in Slovenia is currently in public consultation, proposing sectoral objectives and policy guidelines for 13 sectors (Government of the Republic of Slovenia. http://www.vlada.si/en/projects/previous_projects/climate_change/).

Adaptation objectives and policy guidelines are particularly proposed for the following sectors: agriculture, forestry, sinks and biodiversity, water, health, and natural disasters. Due to above-average exposure of agriculture and forestry to the effects of climate change, the national adaptation strategy for these two sectors was adopted in 2008, followed by an action plan for the years 2010 and 2011.

Mitigation measures are commonly defined as measures taken in advance of drought to lessen impacts when the next drought occurs (Wilhite. 2014). At the moment mainly mitigation

measures for agricultural drought are being developed. For drought risk management of forests in Slovenia only few research projects and publications were found. However, also forest ecosystems are expected to suffer from repeating drought events according to the forecasted significant changes in climate in Slovenia (Kutnar and Kobler. 2011a).

*Lithuania*

The research on possible impact of the predicted climate changes on forests as well as studies concerning favorable ecological (climatic) conditions for native and non-native tree species in Lithuania are already started. The research data showed that the projected climate warming will also affect the distributions of native species in Lithuania. It is also expected that there will be an increase in the proportion of deciduous tree species and at the same time there will be some reduction in coniferous species particularly in Norway spruce (*Picea abies)* and partly in Scots pine (*Pinus sylvestris)* (Ozolinčius et al. 2014). According to the climate change scenario B1, it is espected that the climate of Lithuania in 2031-2060 will be suitable for approximately 5-6 alien species that could become potential immigrants - *Acer campestre, A. pseudoplatanus, Fagus sylvatica, Populus nigra,* and *Prunus avium*. Some studies focus on the impact of artificial drought on Scots pine and Norway spruce stands condition (Ozolinčius et al. 2009; 2012). Changes in tree's crown conditions and the climate change vulnerability of Norway spruce are reported in some publications (Stakėnas et al. 2012, Stakėnas and Žemaitis. 2014). The national project "*The estimation of the impact of climatic changes to the forest ecosystems*" was implemented in 2007-2009 in the Lithuanian Forest Research Institute The project report includes recommendations on the main forestry improvement measures in the context of climate change (Ozolinčius. 2012). The project also inspired to develop the most important statements for the National Forest Sector Development Program for 2012-2020.
In November 2012 the Parliament of Lithuania adopted a „Strategy for National Climate Management Policy 2013-2050". This is an integrated strategy including implementation considerations and it covers both adaptation and mitigation issues in different sectors incl. forestry (Ministry of Environment. 2012).

*Ukraine*

Formation of a national plan of action on adaptation to climate change in Ukraine is under development (Shtets. 2013). In frame of this activity the National Action Plan for implementation of the Kyoto Protocol to the Framework Convention of the UN Convention on Climate Change was approved by government of Ukraine in 2005.
In 2010 the Verkhovna Rada of Ukraine adopted the Law "On Fundamentals (strategy) of the State Environmental Policy of Ukraine till 2020". According to this document, state environmental policy aimed at stabilizing and improving the environment through integration into the socio-economic development of Ukraine to ensure safe environment for human life and health, introduction of ecologically balanced system of environmental management and conservation of natural ecosystems. The issue of climate change adaptation fully complies with the basic principles of environmental policy.
In Ukraine the project „National adaptation plan for climate change to 2020" was developed in 2011, but it hasn't been approved yet. It included propositions for different sectors and policy guidelines. As a part of activity within "National adaptation plan …" the "Plan of priority measures on adaptation to climate change " has been developed and approved by State Agency of Ecology Investment on the base of public consultations and several thematic regional seminars.

The State Target Program “Forests of Ukraine on 2010-2015" has been approved by government (Cabinet of Ministers) in 2009. This program consist the numbers of measures for reducing of greenhouse gas concentrations in the atmosphere - afforestation, improvement of harvesting and use of timber, improve quality and composition of forests, increase their ecological functions and productivity, create conditions for optimization of forest cover.

## 3. Methodology for determination of forest adaptation measures to drought

Analysis of the current forests status in Bulgaria, Slovenia, Lithuania and Ukraine (Milestone 1), implementation of 2014 projections of IPCC AR5 for the expected drought in 2050 - 2070 (Milestone 2), determination of forest vulnerability zones and forest areas and tree species distribution over its (Milestone 3), allow to up-date the national programmes/strategies of adaptation measures, aiming mitigation the drought on forests.
The measures for adaptation are specified in the following vulnerability zones: Zone A – very high level of vulnerability, Zone B – high level of vulnerability, Zone C and Zone D – medium level of vulnerability, Zone E and Zone F – low level of vulnerability, and Zone G – from medium to very high level of vulnerability.
Types of the measures are: normative (N), organisational (O) and investment (I) measure. The leading and assisting institutions are listed, responsible for its implementation. Terms of implementation are foreseen according to local forestry practice. The list of the activities depends on the measure and local conditions.
Programmes of measures for forests adaptation/mitigation to drought in Bulgaria, Slovenia, Lithuania and Ukraine – pilot area according to zones of vulneribility are presented in tables below.
The recommended local measures are addressed to decision makers of the forestry and water management sector, non-state forest owners, municipalities, NGOs and stakeholders in 4 GWP CEE countries. These programmes of forest measures will serve for elaboration of National adaptation strategy on climate change and RBMPs for 2016-2021. These measures are suitable to be used while developing the 10-years forest management plans. They can be used for educational purposes in the forest professional high schools, as well as in the forestry universities.

## 4. Adaptation measures of the forests to drought over vulnerability zones

### *4.1. Bulgaria*

The concrete measures for adaptation of the forests in Bulgaria to drought over vulnerability zones A, B, C, D, E and F according to RCPs of IPCC AR5 in 2050-2070 are shown in Table 4.1. They follow up the former investigation of the experts team (Raev et al. 2011), and assigned to the drought projections of this demonstration project.

### *4.2. Slovenia*

The analysis of the forest vegetation types in Slovenia, the drought conditions, the adopted climate scenarios of IPCC AR5 for the expected climate in 2050 - 2070, as well as the differentiated vulnerability zones of forest vegetation types according to the De Martonne aridity index (IDM) for Slovenia, do allow the development of operational measures for the adaptation of forests, aiming at mitigating negative effects of the drought in forests.

Within the IDMP CEE project, for each vulnerability zone of forest vegetation types in Slovenia (A, B, C, D, E, F and G) specific mitigation measures for drought are listed in Table 4.2. The mitigation measures for drought correspond to forecasted future climate changes in Slovenia. Expert knowledge based on former investigation was included in the development of mitigation measures for drought in forests (Vilhar et al. 2005, Vilhar et al. 2006, Vilhar and Simončič. 2007, Kutnar et al. 2009, Kutnar and Kobler. 2011a, 2011b, Kutnar et al. 2011, Vilhar and Simončič 2012, Kutnar and Kobler. in press).

### *4.3. Lithuania*

The proposed measures for adaptation of the forests in Lithuania to drought over predicted vulnerability zones for 2050 - 2070 (climate scenarios RCP2.6, RCP4.5, RCP6 and RCP8.5) are presented in Table 4.3.

### *4.4. Ukraine*

The measures for adaptation of the Ukrainian forests in the pilot area to drought in 2050 - 2070 over the zones of vulnerability A, B and C are shown in Table 4.4. These measures have been developed on the base of vulnerability assessment for Eastern part of territory of Ukraine within the IDMP CEE project (Buksha et al. in press).

## Table 4.1. Measures for adaptation of the forests in Bulgaria to drought over vulnerability zones in 2050-2070.

| No. | Measure | Type of measure | Institution | | Term of implementation | Activity |
|---|---|---|---|---|---|---|
| | | | Leading | Assisting | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | Identification of sensitive habitat types and selection of appropriate tree and shrub species for forestation according to projected drought (A, B, C, D, E, F) | N O I | MAF/EFA | RFD, SFE/SHE, FRI-BAS, UF | Short term | Updated classification scheme of forest habitats |
| 2 | Develop a programme to create new forest shelter belts in drought conditions (A, B) | N O | MAF/EFA | FRI-BAS, UF | Short term | Developed programme |
| 3 | Developing national and regional programme for forest fire prevention (A, B, C, D, E, F) | N O I | MAF/EFA | RFD, SFE/SHE, Regional and municipal administration | Short term | Specific provisions in the legislation; Developed programme |
| 4 | Timely transformation of coppice into high stem for increasing their sustainability to drought (A, B) | N O | MAF/EFA | RFD, SFE/SHE | Next 15 years | Specific provisions in the legislation; Annually 20 000 ha area transformed from coppice into high stem |
| 5 | Introduction of appropriate tree species for forestation in semi-arid conditions out of NATURA'2000 areas (A) | N O I | MAF/EFA | RFD, SFE/SHE, FRI-BAS, UF | Short term | Specific provisions in the legislation; Number of introduced species: 50 ha annually |
| 6 | Maintaining of mixed character and different age structure of forest through conservation rear and valuable tree species (A, B, C, D, E, F) | N O | MAF/EFA | RFD, SFE/SHE, FRI-BAS, UF | Short term | Specific provisions in the legislation; Implemented pilot project; Saved 400 000 ha mixed forest |
| 7 | Development of information system to find forest's damages caused by drought (A, B, C, D, E, F) | O I | MAF/EFA | RFD, SFE/SHE, Municipalities | Short term | Developed system with data base |
| 8 | Improvement of forest infrastructure to reduce the risk of forest fires and providing access to specialised equipment for forest fire fighting (A, B, C, D, E, F) | N O I | MAF/EFA | RFD, SFE/SHE | Short term | Specific provisions in the legislation; Constructed forest roads |
| 9 | Application of thinnings with intensity, providing more moisture and sustainability (A, B, C, D, E, F) | N O I | MAF/EFA | RFD, SFE/SHE | Short term | Specific provisions in the legislation; Provided thinning; Sustainable stands |
| 10 | Support the natural regeneration of preferred species and if necessary introduction of proven and adaptable to drought native origins and species (A, B, C, D, E, F) | N O I | MAF/EFA | SFE/SHE | Permanent | Specific provisions in the legislation; Introduced adaptable to drought native origins and species |
| 11 | Afforestation which main object is to select the most resistant and prospective plant families, adopted to future drought conditions (A, B) | O I | MAF/EFA | SFE/SHE | Permanent | Number and area afforested cultures; Number of tested and selected origins |
| 12 | Using and adapting the best practices for sustainable management of forest areas and exchange of experience with countries with vast semi-arid areas (Russia, Kazakhstan, Greece, Israel) (A) | O I | MAF/EFA | SFE/SHE, FRI-BAS, UF, Municipalities, | Permanent | Implemented best practices |

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| | | | | land and forest owners | | |
| 13 | Development of functioning system for finance support of good sylvicultural practices in non-state forests as a tool to improve the common sustainability of forests to drought (A, B, C, D, E, F) | N<br>O<br>I | MAF/EFA | FPS, FRI-BAS, UF, experts, municipalities, forest owners | Short term | Issued a legal text; Implemented pilot project; Functioning system for support |
| 14 | Monitoring of forest ecosystems with emphasize on their drying (A, B, C, D) | N<br>O | MAF/EFA | | Permanent | Specific provisions in the legislation |
| 15 | Implementation of new technologies to recover damages from fires (A, B, C, D, E, F) | N<br>O | MAF/EFA | MEW, Municipalities, land and forest owners | Permanent | Specific provisions in the legislation; Number of implemented new technologies; Recovered damaged soils |
| 16 | Increasing the knowledge about the effect of drought on forests and their sustainable management (A, B, C, D, E, F) | O<br>I | MAF/EFA | RFD, SFE/SHE, FRI-BAS, UF, NGOs, experts, media | Permanent | Increased knowledge. Provided results from researchers; Maintaining of information systems |
| 17 | Training and media activity to form the public interests in prevention of forest fires (A, B, C, D, E, F) | O<br>I | MAF/EFA | RFD, SFE/SHE, FRI-BAS, UF, NGOs, experts, media | Permanent | Increased public interest and awareness; Designed electronical and informational packages; Issued and published printed materials; Organized workshops |
| 18 | Developed and implemented training system for employers and volunteers engage to prevent forest from fires (A, B, C, D, E, F) | O<br>I | MI, GD „FSPP“, MAF/EFA | RFD, SFE/SHE, regional and municipality administration | Permanent | Developed and operational training system |
| 19 | Implementation of integrated management of forest basins (B, C, D, E, F) | N<br>O | MAF/EFA, MEW | RFD, SFE/SHE, regional and municipal administration | Permanent | Specific provisions in the legislation; Number of basins with integrated management; IWRM |
| 20 | Planting and maintaining of ecological plant stock gardens from selected drought resistant origins of specific species (B, A, C, D) | N<br>O<br>I | MAF/EFA | SFE/SHE, forest owners | Permanent | Specific provisions in the legislation; Number of plant stock gardens |
| 21 | Forest certification and certification of timber processing companies in order to guarantee proper and close to nature management (B, C, D, E, F) | O<br>I | MAF/EFA | SFE/SHE, forest owners, authorities providing forest certification | Long term to 2030 | Total area of certificated state and non-state forests; Percentage of growing stock and annual use in certificated forest enterprises; Percentage of harvested timber from certificated companies |
| 22 | Maintaining forest ecosystems in sanitary protection zones of dams (B, C, D) | N<br>O | MEW, MAF/EFA | MRDPW, Dams and Cascades Enterprise, Municipalities | Permanent | Specific provisions in the legislation; Provided activities in sanitary protection zones |

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| 23 | Motivated afforestation and regeneration of forest monocultures over infertile lands incl. dams water catchments by implementation of special tools for finance the activities | O<br>I | MAF/EFA | MEW, MRDPW, Municipalities, land and forest owners | Permanent | Implemented financial frameworks; Number of granted projects |
| 24 | Priority afforestation and regeneration of burned forests, non-regenerated cutting areas, forest fertile areas, erosion and infertile terrains which are close to living areas (B, C, A, D) | N<br>O<br>I | MAF/EFA | SFE/SHE, Municipalities, Land and forest owners | Permanent | Specific provisions in the legislation; Provided afforestation and regeneration – 300 ha annually |
| 25 | Implementation of appropriate regimes to manage forests which are part of Natura'2000 and damaged from drought (B) | N<br>O | MAF/EFA, MEW | SFE/SHE, Municipalities, Forest owners | Permanent | Specific provisions in the legislation |
| 26 | Protecting of wetlands if it's necessary by planning native tree and shrub species and supporting their regeneration (B, A) | O<br>I | MAF/EFA, MEW | SFE/SHE, Municipalities, NGOs | Permanent | Restored wetlands |
| 27 | Providing complex activities in order to preserve the forest and agriculture fund at water basin level (B, C, D, E, F) | O<br>I | MAF/EFA | MRDPW, Municipalities, Private owners | Permanent | 10 implemented integrated project (IWRM) |
| 28 | Improving the health status of oak forests through differentiated approach according to the origin, structure, age, and regeneration processes in stands (B, C, D) | O | MAF/EFA | MHC, FPS, SFE/SHE | Permanent | Implemented differentiated approach |
| 29 | Implementation of sylviculture systems in order to provide preliminary natural regeneration of forests (C, D, E, F) | N<br>O | MAF/EFA | RFD, SFE/SHE | Permanent | Specific provisions in the legislation; Provided natural regeneration |
| 30 | Implementation of new forest management methods which have optimal ecological and economic effect (sylviculture through constant forest cover, close to nature forest management, ecological forestry and management of riparian forests) (C, B, D, E, F) | N<br>O | MAF/EFA | RFD, SFE/SHE | Permanent | Specific provisions in the legislation; Specific provisions in the legislation; New methods of forest management |
| 31 | Keeping higher rotating ages in some forests of oak, beech, Scotch pine, spruce to increase water protection role and carbon accumulation in water basins (C, D, E, F) | N<br>O | MAF/EFA | RFD, SFE/SHE, FRI-BAS, UF | Permanent | Specific provisions in the legislation; Implemented pilot project |
| 32 | Preserving the natural character of forest ecosystems in conditions of drought by using of appropriate sylvicultural activities (C, B, D, E, F) | N<br>O | MAF/EFA | SFE/SHE, FRI-BAS, UF | Permanent | Specific provisions in the legislation; Implemented pilot project |
| 33 | Facilitate the migration of forest tree species at higher altitude providing sylvicultural activities (C, D, E, F) | N<br>O | MAF/EFA | FRI-BAS, UF, SFE/SHE | Permanent | Specific provisions in the legislation; Implemented pilot project |
| 34 | Coordinated actions to limit consequences of drought , which have affected forests with economic functions in protected areas (E and F) | N<br>O | MAF/EFA, MEW | SFE/SHE, Companies | Permanent | Specific provisions in the legislation; Inter-institutional agreement; Harvested fresh damaged timber up to one year after its damaging |

**Table 4.2. Measures for adaptation of the forests in Slovenia to drought over vulnerability zones in 2050-2070.**

| No. | Measure | Type of measure | Institution | | Term of implementation | Activity |
|---|---|---|---|---|---|---|
| | | | Leading | Assisting | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | Reconsideration/developing of strategic documents and policies in the forest sector according to assessed effects of climate change and forecasted worsening of site/stand conditions in the forest area (B, C, D, E, F, G) | N O | MAFF | EAS, MESP, UL, SFI, SFS, etc. | Short term | A new action plan for forest sector; A strategy to reduce the risk of pests and pathogens in forest; Strategy for sustainable development of carbon sequestration; Strategy for fire forest prevention |
| 2. | Forest management planning and silvicultural activities to strength the sustainability and drought resistance of forests (B, C, D, E, F, G) | N O I | MAFF / SFS | UL, SFI | Short term | Specific provisions in the legislation; Operating system for control of implementation |
| 3. | Establishment or improvement of seasonal and shorter-term drought forecasts (B, C, D, E, F, G) | N O I | MAFF / EAS | MESP, UL, SFI, SFS, etc. | Short-term | Preparation of climatological, hydrological, soil and vegetation datasets; Updated drought stress indices for forests |
| 4. | Adjustment/developing of unified system for monitoring, early detection and forest fire alarm (B, C, D, E, F, G) | N O I | MAFF / ACPDR | SFI, SFS, EAS | Short term | Specific provisions in the legislation; Developed and working system |
| 5. | Reconsideration/developing national and regional programme for forest fire prevention (B, C, D, E, F, G) | N O I | MAFF / ACPDR | SFI, SFS, EAS | Short term | Specific provisions in the legislation; Developed programme |
| 6. | Reconsideration/developing of the system for forest restoration after large-scale disturbances (drought, forest fires, pest and diseases etc.) (B, C, D, E, F, G) | N O I | MAFF / SFS | UL, SFI, FE, forest owners, | Short term | Specific provisions in the legislation; Developed system for forest restoration |
| 7. | Identification of sensitive forest sites, forest types and species, provenances (B, C, D, E, F) | N O I | SFS / SFI / UL | MAFF | Short-term | Updated classification scheme of forest sites, types, species and provenances |
| 8. | Selection of drought tolerant tree and shrub species, and provenances appropriate for implementation in forests in vulnerability zones B, C, D | N O I | SFS / SFI / UL | MAFF | Short-term | List of drought tolerant species and provenances |
| 9. | Maintaining of diverse vertical and horizontal structures with balance of forest developmental phases (B, C, D, E, F, G) | N O I | MAFF / SFS | UL, SFI, FE, forest owners | Permanent | Specific provisions in the legislation; Multilayered forest stands; |

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| | | | | | | Uneven aged forests |
| 10. | Maintaining of mixed forests stands, and natural regeneration (B, C, D, E, F, G) | N O I | MAFF / SFS | UL, SFI, FE, forest owners, | Permanent | Specific provisions in the legislation; Mixed forest; Share of young forests with natural regeneration |
| 11. | Establishment of integrated monitoring and drought early-warning system (B, C, D, E, F, G) | N O I | EAS / ACPDR / MAFF / SFS | UL, SFI | Permanent | Operational monitoring of drought in forests; Definition of drought stress indices range/interval; Early-warning system for drought in forests |
| 12. | Development of drought mitigation measures and implementation at various levels of forest management planning (B, C, D, E, F, G) | N O I | SFS / SFI / UL | MAFF | Permanent | Mitigation measures for main forest vegetation types; Drought mitigation plans at national level, forest management unit level, forest owner level, etc. Detailed forestry management plans with adopted drought mitigation measures. |
| 13. | Monitoring of the effects of drought mitigation plans (B, C, D) | N O I | SFS / SFI / UL | MAFF | Every 3-5 years | Operational monitoring of the effects of drought mitigation measures. |
| 14. | Adjustment of periodic flooding in riparian forests with opening temporary dike in drought period and constructing special channels in order to protect riparian habitats (B, C, D) | N O I | SFS / SFI / UL / IRSNC | FE, forest owners | Short term | Regulations; Inter-institutional agreement; Implemented pilot project |
| 15. | Building awareness and education among forest practitioners and general public (B, C, D, E, F, G) | N O I | SFS / MAFF | SFI / UL / IRSNC / FE, forest owners | Permanent | Dissemination activities; Educational programmes. |

## Table 4.3. Measures for adaptation of the forests in Lithuania to drought over vulnerability zones in 2050-2070.

| No. | Measure | Type of measure | Institution | | Term of implementation | Activity |
|---|---|---|---|---|---|---|
| | | | Leading | Assisting | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1. | Identification of sensitive habitat types and selection of appropriate tree and shrub species for forestation (A, B, C) | N O I | ME | LFRI, SFS, DGSF | Short term | Developed pilot project. Updated classification scheme of adapted tree species for relevant forest types |
| 2. | Developing of investigations, policies and strategic documents in the forest sector according to predicted worsening of forests and tree conditions (A, B, C, D) | N O I | ME | LFRI, SFS, DGSF, etc. | Short term | Developed pilot project. Investigations of the risk of pests and pathogens in forest. To develop the strategy for magnification of carbon sequestration in forest ecosystems and preparation of strategy for fire forest prevention |
| 3. | Development investigations of impact of logging residues to forest site conditions and forests biodiversity (A, B, C, D, E) | N O I | ME/ DGSF | LFRI, SFS, | Permanent | Developed pilot project. Specific provisions in the legislation. |
| 4. | Expand the forest area in unsuitable for agriculture lands (A, B, C, D, E) | O I | MA/ME | DGSF, SFS | Permanent | Forest area in percent of total land area |
| 5. | Developing the national programme for forest fire forecast and prevention according to forest site humidity (A, B, C, D, E) | N O I | ME/ DGSF | LFRI, SFS, FE | Short term | Specific provisions in the legislation; Developed programme. Scientific investigations. |
| 6. | Purchase of techniques and equipment to monitor, control and fighting forest fires (A, B, C, D, E) | O I | ME/ DGSF | FE, MF | Short term | Purchased ground and air techniques and equipment |
| 7. | Public education and training to prevent and extinguish fires (A, B, C, D, E) | N O I | ME/ DGSF | SFS, etc. | Short term | Providing education and trainings. Formed voluntary groups |
| 8. | Introduction of appropriate tree species for forestation in semi-arid conditions (A, B) | N O I | ME/ DGSF | LFRI, SFS | Short term | Scientific investigations. Specific provisions in the legislation. List of introduced species. |
| 9. | Mixing of forests tree species composition (A, B, C, D) | N O | ME/ DGSF | SFS, FE | Permanent | Implemented pilot project. Specific provisions in the legislation |
| 10. | Develop and implement a system to assess current fire danger and forest fire risk (A, B, C, D, E) | O I | ME/ DGSF | SFS, FE | Short term | Implemented system |
| 11. | Reconstruction and creating new wind shelterbelts along boundaries of agricultural lands, channels, roads etc, (A, B, C) | O I | ME/ DGSF | SFS, FE Owners, Municipalities | Permanent | Km annually planted shelterbelts along agricultural lands, channels and roads |
| 12. | Support the natural regeneration of preferred species and if necessary introduction of proven and adaptable native origins and species (A, B, C, D, E) | N O I | ME/ DGSF | SFS/FE | Permanent | Specific provisions in the legislation. Introduced adaptable native origins and species |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13. | To provide and develop forest health monitoring (A, B, C, D, E) | O<br>I | ME/SFS | LFRI | Permanent | Forest health monitoring data sets. Trends of forest condition changes. |
| 14. | Development of the international cooperation in sustainable development of forests between countries with semi-arid forest areas (A, B, C, D, E) | N<br>O<br>I | ME/<br>DGSF | MA, LHS, LFRI | Permanent | Implementation of experiences and practices |
| 15. | Monitoring of the damaging pathogens and pests (A, B, C, D, E) | O<br>I | ME/SFS | LFRI | Permanent | Regional (systematic) assessment and monitoring of selected areas |
| 16. | Monitoring of forest vegetation (lichens, mosses, grasses, shrubs and trees) abundance and diversity (A, B, C, D, E) | O<br>I | ME/SFS | LFRI | Permanent<br>(every 5 years) | Data set of experimental Level II forest monitoring plots and Integrated monitoring (basins) territories |
| 17. | Permanent inventory of carbon stock in the components (vegetation and soil) of forest ecosystems (A, B, C, D, E) | N<br>O<br>I | ME/SFS | | Permanent | Monitoring of carbon stocks in ecosystems. Analysis of data and recommendations. |
| 18. | Preservation and development of existing gene fund of native forest vegetation species (A, B, C, D, E) | N<br>O<br>I | ME/MA | PGB, SFS | Permanent | Provisions in the legislation; Gene conservation of endangered species and native populations. |
| 19. | Trainings, supplying information due to increasing the competence of society and professionals (including researchers) about the ecological effect of climate conditions (especially drought) on forests and their sustainable management (A, B, C, D, E) | N<br>O<br>I | ME/MES | Universities and High Schools, Researchers experts | Permanent | Provided results from researchers. Increased competence. Improved administrative capacity. Support and maintaining of information systems |
| 20. | Training and media activity to form the public interests in prevention of forest disturbances and forest fires (A, B, C, D, E) | N<br>O<br>I | ME/MES | Universities and High Schools, Researchers experts | Permanent | Provided results from researchers. Increased competence. Issued and published printed materials. Organized workshops |
| 21. | Expand and promote forest certification order to guarantee environment friendly forest management (A, B, C, D, E) | O<br>I | ME/ DGSF | FE, owners | Permanent | Total area of certificated state and non-state forests. Amount of growing stock and annual timber use in certificated forest enterprises and non-state forests. |
| 22. | Maintaining forest ecosystems in sanitary protection zones of large industrial enterprises (A, B, C, D, E) | O<br>I | ME | Enterprises, Municipalities | Permanent | Provided forest monitoring in sanitary protection zones. Legislation. |
| 23. | Support regeneration of native species in protected peatlands and wetlands (C, D, E) | O<br>I | ME | SFS, FE | Permanent | Maintaining wetlands and peatlands |
| 24. | Maintaining high rotating ages in oak, ash, Scotch pine and Norway spruce stands to keeping biodiversity, increase water protection and carbon accumulation in forests (A, B, C, D, E) | N<br>O | ME/ DGSF | SFS, FE, owners | Permanent | Specific provisions in the legislation. |
| 25. | Uphold wind and snow resistant tree species with deep root systems by afforestation and timely provided thinnings (C, D, B, A, E) | N<br>O | ME/ DGSF | SFS, FE, owners | Permanent | Selection of resistant tree species. |
| 26. | Develop using game trees to control the most aggressive bark beetles (Yps typhographus) insects | N<br>O, I | ME/ DGSF | SFS, FE, owners | Permanent | Limited bark beetle infected sites |

## Table 4.4. Measures for adaptation of the forests in the pilot area of Ukraine to drought over vulnerability zones in 2050-2070.

| No. | Measure | Type of measure | Institution | | Term of implementation | Activity |
|---|---|---|---|---|---|---|
| | | | Leading | Assisting | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1. | Reconsideration/developing of strategic documents and policies in the forest sector according to forthcoming worsening of forest condition (A, B.C). | N<br>O | MAPF/ SAFR | MENR, MRDCHU, MEDT, MHC, MTITC etc. | Short term | A new action plan for forest sector; A strategy to reduce the risk of pests and pathogens in forest; Strategy for sustainable development of carbon sequestration; Strategy for fire forest prevention |
| 2. | Develop a programme to create new forest shelter belts (A, B,C). | N<br>O | MAPF/ SAFR | URIFFM, UF | Short term | Developed programme |
| 3. | Reconstruction and maintaining of existing forest shelter belts, and creation new forest shelterbelts (A, B.C). | O<br>I | MAPF/ SAFR MRDCHU | RFHA, SFE/SHE, Municipalities Lands owners | Permanent | 100 ha annually; Reconstructed and maintained shelter belts; 30 ha annually planted shelterbelts |
| 4. | Monitoring of forest ecosystems, inventory of forest carbon stock (A, B.C). | N<br>O | MAPF/ SAFR, MENR | RFHA, SFE/SHE, URIFFM | Permanent | Data of monitoring and inventory; Analysis and recommendations for the accumulation and storage of carbon |
| 5. | Developing national and regional programme for forest fire prevention (A, B.C). | N<br>O<br>I | MAPF/ SAFR | RFHA, SFE/SHE, Regional and municipal administration | Short term | Specific provisions in the legislation; Developed programme |
| 6. | Develop the system for monitoring , early detection and forest fire alarm, provision of specialized ground and air techniques and equipment (A, B.C). | N<br>O<br>I | MAPF/ SAFR | SSE, UHMI, SFE/SHE | Short term | Specific provisions in the legislation; Developed and working system Purchased ground and air techniques and equipment |
| 7. | Development of information system to find forest's damages caused by biotic and abiotic factors, and coordinated actions to limit consequences of natural disasters, which have affected forests with economic functions in protected areas (A, B.C). | N<br>O<br>I | MAPF/ SAFR, MENR | URIFFM, SFE/SHE, Municipalities, Companies | Permanent | Specific provisions in the legislation; Developed system with data base and specific measures |
| 8. | Protection of vital forests through friendly sylvicultural activities (A, B, C) | N<br>O<br>I | MAPF/ SAFR | URIFFM, UF, SFE/SHE | Short term | Specific provisions in the legislation; Developed pilot project |
| 9. | Testing sustainability and producing capabilities of some drought-resistant trees and shrubs, Wide use of appropriate drought-resistant tree species for forestation in semi-arid conditions (A) | N<br>O<br>I | MAPF/ SAFR | URIFFM, UF RFHA, SFE/SHE, | Short term | Implemented pilot project; Issued legislative document; The area of experimental cultures; Number of introduced species: 50 ha annually |

| No. | Measure | Type of measure | Institution | | Term of implementation | Activity |
|---|---|---|---|---|---|---|
| | | | Leading | Assisting | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 10. | Preservation of existing gene fund of native tree and shrub species by providing sylvicultural activities (A, B,C) | N<br>O<br>I | MAPF/ SAFR | URIFFM, UF, FSCS, MENR | Permanent | Specific provisions in the legislation; Implemented pilot project, Preserved biodiversity; |
| 11. | Using and adapting the best practices for sustainable management of forest areas in conditions of climate changes and exchange of experience with countries with vast semi-arid areas (Bulgaria, Romania, Greece, Israel) (A) | O<br>I | MAPF/ SAFR | SFE/SHE, URIFFM, UF, Municipalities | Permanent | Implemented best practices |
| 12. | Development of functioning system for state finance support, and mechanisms of international support of sylvicultural practices in forests as a tool to improve the common sustainability of forests (A, B, C) | N<br>O<br>I | MAPF/ SAFR | RFHA, URIFFM, UF, experts, municipalities, forest owners etc. | Short term | Issued a legal text; Implemented pilot project; Functioning system for support |
| 13. | Monitoring over rare species and migration of xerophyte tree and shrub species (A) | O<br>I | MENR, MAPF/ SAFR | RFHA, SFE/SHE, URIFFM, UF | Every 5 years | Number of reports of provided monitoring |
| 14. | Protecting of wetlands by creation of protective forest stands from native species, supporting their regeneration, maintaining of hydraulic structures in floodplains, implementation of dual water regime in floodplains (B, C) | N,<br>O<br>I | MAPF/ SAFR, MENR | SAWR, RFHA, SFE/SHE, Municipalities, NGOs | Permanent | Restored wetlands; Network of riverside belts with dense structure; |
| 15. | Increasing and maintaining the forest cover through new afforestation and by limiting the transformation of forests into other lands, implementation of special tools for finance the activities (B, C) | O<br>I | MAPF/ SAFR, MENR | RFHA, SFE/SHE, Municipalities land and forest owners | Permanent | 100 ha annually; Implemented financial frameworks; |
| 16. | Identification of sensitive habitat types and selection of appropriate tree and shrub species for forestation, types of forest cultures and mixing schemes (B, C) | N<br>O<br>I | MAPF/ SAFR | RFHA, SFE/SHE, URIFFM, UF | Short term, Permanent | Updated classification scheme of forest habitats Number and area afforested cultures; Number and area afforested ancestral experiences; Number of tested and selected origins |
| 17. | Improvement of hydrological regime and ecological state of the rivers Siversky Donets, Vorskla, Psel and other (B, C) | N<br>O | MENR, SAWR | RBDs, Municipalities | Short term | Water quality and river level. |
| 18. | Providing complex activities against erosion in order to preserve soils in forest and agriculture fund on water basin level (B, C) | O<br>I | MAPF/ SAFR | MRDPW, Municipalities, | Permanent | 10 implemented integrated project (IWRM) |

| No. | Measure | Type of measure | Institution | | Term of implementation | Activity |
|---|---|---|---|---|---|---|
| | | | Leading | Assisting | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | | | | Land and forest owners | | |
| 19. | Improvement of forest infrastructure for sustainable forest management (B, C) | N O I | MAPF/ SAFR | RFHA, SFE/SHE | Permanent | Specific provisions in the legislation; Constructed forest roads |
| 20. | Forest pathological monitoring of pests and diseases in forests, including aggressive insect pests and pathogens, and (pests) causing allergies and other health problems, forecasting and control (B, C) | N O I | MAPF/ SAFR, National service for plant protection | FPE, URIFFM, UF, MHC | Permanent | Specific provisions in the legislation; Strategy to reduce the risk of pests and pathogens in forests; Regular monitoring; Protection of forests from insects with allergic influence on people |
| 21. | Knowledge dissemination and media activity to form the public interests to conservation of forests<br>Developed and implemented training system for employers and volunteers engage in forest protection and conservation(B, C) | O I | MAPF/ SAFR | RFHA, SFE/SHE, URIFFM, UF, NGOs, experts, media | Permanent | Increased public interest and awareness; Designed electronical and informational packages; Issued and published printed materials; Organized workshops and trainings |
| 22. | Using tree species with deep root systems for afforestation in regions with heavy snow and wind falls and timely provided thinnings (B, C) | N O | MAPF/ SAFR | SFE/SHE | Permanent | Specific provisions in the legislation; Selection of appropriate species; Growing of sustainable forest stands |
| 23. | Application of modern technologies for soil preparation which ensure protection and improvement of soil structure, moisture and fertility (B) | N O I | MAPF/ SAFR | RFHA, SFE/SHE | Permanent | Specific provisions in the legislation; 1000 ha annually; Implemented best practices in order to storage soil carbon |
| 24. | Implementation of appropriate regimes to manage forests which are part of nature reserve fund and damaged by climate changes (B) | N O | MAPF/ SAFR, MENR | SFE/SHE, Municipalities, Forest owners | Permanent | Specific provisions in the legislation |
| 25. | Recovering of polluted soils in forest fund through the implementation of best practices (B) | O I | MAPF/ SAFR | MENR, MRDPW, MHC | Permanent | 50 ha annually; Implemented best practices |
| 26. | Maintaining forest ecosystems in sanitary protection zones of water reservoir (B) | N O | MENR, MAPF/ SAFR | MRDCHU, SAWR, Municipalities | Permanent | Specific provisions in the legislation; Provided activities in sanitary protection zones |
| 27. | Priority afforestation and regeneration of burned forests, non regenerated cutting areas, erosion and infertile terrains which are close to living areas (B) | N O I | MAPF/ SAFR | SFE/SHE, Municipalities, Land and forest owners | Permanent | Specific provisions in the legislation; Provided afforestation and regeration – 200 ha annually |

| No. | Measure | Type of measure | Institution | | Term of implementation | Activity |
|---|---|---|---|---|---|---|
| | | | Leading | Assisting | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 28. | Increasing the density of low-density forest stands, keeping higher rotating ages in some forests of oak, Scotch pine to increase water protection role and carbon accumulation (C) | N<br>O | MAPF/<br>SAFR | SFE/SHE, URIFFM, UF, Municipalities, Forest owners | Permanent | Specific provisions in the legislation; Stimulation of natural regeneration; Implemented pilot project |
| 29. | Forest certification and certification of timber processing companies in order to guarantee proper and close to nature management, differentiated payment in timber harvesting services, using ecological friendly technologies (C) | N<br>O<br>I | MAPF/<br>SAFR | SFE/SHE, forest owners, companies, company providing forest certification, URIFFM | Long term | Issued legal text , Total area of certificated state and non-state forests, Developed financial mechanisms. |
| 30. | Improvement of agro technique and equipment in forest nurseries by providing soil treatment and production of forest seed materials (qualities and quantities) (C) | O<br>I | MAPF/ SAFR | SFE/SHE, Municipalities, nurseries owners, FSCS | Permanent | Using best practices; Purchased new equipment; Optimal area for nursery activities |

## 5. Conclusions

The main adaptation/mitigation measures of the forests to drought over vulnerability zones in 4 GWP CEE countries for the period 2050-2070 (Bulgaria – 34 measures, Ukraine – 30, Lithuania – 26 and Slovenia – 15) are defined.

As a result, the common interest for follow-up pilot projects is as follows:

- Identification of sensitive habitat types and selection of appropriate tree and shrub species for forestation in areas, threatened by repeating droughts;
- Developing of the system for forest restoration after large-scale disturbances, induced by repeating drought (e.g. forest fires, pest and diseases, invasive species, etc.);
- Development of monitoring the impact of logging residues to forest site conditions and forests biodiversity;
- Providing complex activities in order to preserve the forest fund at water basin level;
- Keeping higher rotating ages in some forests of oak, beech, Scotch pine, spruce to increase water protection role in water basins;
- Restoration of wetlands by promoting native tree and shrub species and supporting their natural regeneration.

## References

Buksha, I., Pyvovar, T., Buksha, M. (in press.). Vulnerability assessment of forests to the drought on base of using GIS technology: case study for eastern Ukraine. In: Scientific Proceedings of Forestry Science Academy of Ukraine: No 12

EC. 2013. Guidelines on developing adaptation strategies. Commission staff working document. p. 54

Executive Forestry Agency. Forest Documents. http://www.iag.bg/docs/lang/1/cat/5/index

Government of the Republic of Slovenia. Past projects: Climate change. http://www.vlada.si/en/projects/previous_projects/climate_change/

Kutnar, L., Kobler, A. (in press). Possible impacts of global warming on forest tree species composition in Slovenia. Catena, Advances in GeoEcology 43

Kutnar, L., Kobler, A. 2011a. Prediction of forest vegetation shift due to different climate-change scenarios in Slovenia. Šumarski list 135, 113-126

Kutnar, L., Kobler, A. 2011b. What might be the effects of climate change on the forest vegetation pattern in Slovenia? In: H B Zamudio (eds), Bosques del Mundo, cambio climático y amazonía, Cátedra UNESCO, 71-86

Kutnar, L., Kobler, A., Bergant, K. 2009. Vpliv podnebnih sprememb na pričakovano prostorsko prerazporeditev tipov gozdne vegetacije. Zbornik gozdarstva in lesarstva 89, 33-42

Kutnar, L., Kobler, A., Krajnc, N., Simončič, P. 2011. Prilagajanje gospodarjenja z gozdovi podnebnim spremembam glede na pričakovane spremembe značilnosti in prostorske razporeditve gozdov. Adaptation of forest management to climate changes in relation to expected changes of forest traits and forest spatial changes. Zaključno poročilo o rezultatih opravljenega raziskovalnega projekta v okviru Ciljnega raziskovalnega programa (CRP) "Konkurenčnost Slovenije 2006-2013" (Final project report). Gozdarski inštitut Slovenije, Ljubljana: 30, 39, 31, p. 25

Ministry of Environment. 2012. Lithuanian climate change management policy and its implementation. Leaflet, www.am.lt

Ozolinčius, R. 2012. Possible effects of climate change on forest biodiversity, tree growth and condition: review of research in Lithuania. Baltic Forestry, v. 18, N 1, 156-167

Ozolinčius, R., Stakėnas, V., Varnagirytė-Kabašinskienė, I., Buožytė, R. 2009. Artifical drought in Scots pine stands: effects on soil, ground vegetation and tree condition. Ann. Bot. Fennici, 46, 299-307

Ozolinčius, R., Stakėnas, V., Varnagirytė-Kabašinskienė, I., Buožytė, R., Aleinikovienė, J. 2012. Dirbtinės sausros poveikis eglyno ekosistemai: dirvožemio savybių, gyvosios dirvožemio dangos, medžių būklės ir nuokritų pokyčiai. Miškininkystė Nr.2 (72), 7-19 (in Lithuanian)

Ozolinčius, R., Lekevičius, E., Stakėnas, V., Galvonaitė, A., Samas, A., Valiukas. 2014 Lithuanian forests and climate change: possible effects on tree species composition. European Journal of Forest Research, Volume 133, Issue 1, 51-60

Raev, I., Zhelev, P., Grozeva, M., Georgiev, G., Alexandrov, V., Jianski, M., Markov, I., Velichkov, I., Miteva, S. 2011. Programme of measures for adaptation of the forests in the Republic of Bulgaria and mitigation the negative effect of climate change on them. EU Interreg IVC, FUTUREforest, S., p.194

Republic of Bulgaria. 2013. National strategy for forest sector development in Republic of Bulgaria for the period 2013-2020. Ministry of Agriculture and Foods, p. 207

Shtets, V. 2013. Adaptation of Ukraine to consequences of climate change. Economics of environment and environment protection. 234 – 240. http://economics-of-nature.net/uploads/arhiv/2013/Shtets.pdf (In Ukrainian)

Stakėnas, V., Žemaitis, P., Ozolinčius, R. 2012. Crown condition of Norway spruce (Picea abies (L.) H. Karst.) in different ecoclimatic regions of Lithuania: possible effects of meteorological factors. Baltic Forestry, v. 19, N 2, 187-195

Stakėnas, V., Žemaitis, P. 2014. Meteorological Factors and Norway Spruce Condition: Role of Site Humidity. Russian Journal of Ecology, Vol. 45, No. 6, 517–524

Vilhar, U., Simončič, P. 2007. Podnebne spremembe in suša v dinarskem jelovo-bukovem gozdu v Kočevskem Rogu. Climate changes and draught in Dinaric silver fie - beech forest in Kočevski Rog. In: M Jurc (eds), Podnebne spremembe: vpliv na gozd in gozdarstvo. Climate change: impact on forest and forestry, Biotehniška fakulteta, Oddelek za gozdarstvo in obnovljive gozdne vire. Biotechnical Faculty, Department of Forestry and Renewable Forest Resources, Ljubljana, 130, 381-397

Vilhar, U., Simončič, P. 2012. Water status and drought stress after gap formation in managed and semi-natural silver fir - beech forests. European Journal of Forest Research 131, 1381-1397

Vilhar, U., Simončič, P., Kajfež-Bogataj, L,. Katzensteiner, K., Diaci, J. 2006. Influence of forest management practice on water balance of forest in the dinaric karst. All about karst & water: decision making in a sensitive environment Vienna, 09.-11.10.2006: 290-295

Vilhar, U., Starr, M., Urbančič, M., Smolej, I., Simončič, P. 2005. Gap evapotranspiration and drainage fluxes in a managed and a virgin dinaric silver fir–beech forest in Slovenia: a modelling study. European Journal of Forest Research 124, 165-175

Wilhite, D. 2014. National Drought Management Policy Guidelines - A Template for Action. Tools and Guidelines Series 1. WMO/GWP Integrated Drought Management Programme (IDMP), WMO, Geneva, Switzerland and GWP, Stockholm, Sweden