Appendix A

Harmonia^{+PL} – procedure for negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland

QUESTIONNAIRE

A0 | Context

Questions from this module identify the assessor and the biological, geographical & social context of the assessment.

a01. Name(s) of the assessor(s):

first name and family name

1. Maciej Gąbka – external expert
2. Ryszard Kamiński – external expert
3. Barbara Tokarska-Guzik

acomm01. Comments:

	degree	affiliation	assessment date
(1)	dr hab.	independent expert	24-01-2018
(2)	dr	Botanic Garden, Faculty of Biology, University of Wrocław	21-01-2018
(3)	prof. dr hab.	Faculty of Biology and Environmental Protection, University of Silesia in Katowice	01-02-2018

a02. Name(s) of ***the species*** under assessment:

Polish name: Eichornia gruboogonkowa

Latin name: ***Eichhornia crassipes*** (Mart.) Solms

English name: Water-hyacinth

Współfinansowano w ramach projektu nr POIS.02.04.00-00-0100/16 pn. *Opracowanie zasad kontroli i zwalczania inwazyjnych gatunków obcych wraz z przeprowadzeniem pilotażowych działań i edukacją społeczną* ze środków Unii Europejskiej w ramach Programu Infrastruktura i Środowisko 2014-2020

acomm02. Comments:

The Latin name of the species is given according to International Plant Names Index (2005 – I) and The Plant List (2013 – B).

There are more synonims for latin names (e.g. CABI 2017, The Plant List 2013 – B, Missouri Botanical Garden 2018 – I): in addition to the following: *Eichhornia crassicaulis* Schltdl., *Eichhornia speciosa* Kunth, *Heteranthera formosa* Miq., *Piaropus crassipes* (Mart.) Raf., *Piaropus mesomelas* Raf., *Pontederia crassicaulis* Schlecht., *Pontederia crassipes* Roem. & Schult., *Pontederia elongata* Balf.

Polish names: 'eichhornia gruboogonkowa' – according to Szweykowska and Szweykowski (2003 – I), 'pontederia gruboogonkowa' – according to Jańczyk-Węglarska (2008 – I), 'hiacynt wodny' (direct translation of the English name) – the most popular Polish name, of an unknown etymology, probably derived from the biological features of the plant (the name refers to the similarity of plant inflorescences to hyacinth inflorescences (*Hyacinthus*), used by Szweykowska and Szweykowski (2003 – I).

English names: in addition to those listed below: lilac devil, Nile Lily, pickerelweed, water orchid, water violet (KABI 2017 – B).

Note: in this paper two most popular names are used: latin name *Eichhornia crassipes* and polish

Polish name (synonym I) Hiacynt pływający, Hiacynt wodny	Polish name (synonym II) Pontederia gruboogonkowa
Latin name (synonym I) *Eichhornia cordifolia*	Latin name (synonym II) *Eichhornia crassicaulis*
English name (synonym I) Common water hyacinth	English name (synonym II) Floating water hyacinth

a03. **Area** under assessment:

Poland

acomm03. Comment:

–

a04. **Status** of *the species* in Poland. *The species* is:

	native to Poland
	alien, absent from Poland
	alien, present in Poland only in cultivation or captivity
X	alien, present in Poland in the environment, not established
	alien, present in Poland in the environment, established

aconf01. Answer provided with a

low	medium	high
		X

level of confidence

acomm04. Comments:

In Poland, the species is cultivated in tropical greenhouses of botanical gardens, greenhouses and reservoirs of open horticultural farms and home gardens, where it is planted in warm spring months in ponds. Currently, there is no information on the occurrence of the species in the natural environment (on domestic sites) outside cultivation. Eichhornia srassipes (water hyacinth) was proved to occur only in thermally changed (heated) lakes of the cooling cycle of the power plants near Konin (Babko et al. 2010 – P). Despite the increased temperature of the water, the species is not established in these lakes (Gąbka 2010-2017 – A). However, it is necessary to control the presence of *Eichhornia crassipes* in terms of thermally polluted waters.

a05. The impact of *the species* on major domains. *The species* may have an impact on:

X	the environmental domain
X	the cultivated plants domain
X	the domesticated animals domain
X	the human domain
X	the other domains

acomm05. Comments:

In Poland, the impact of the species on the natural environment and other spheres is marginal and limited only to the water reservoirs in which it is cultivated; in the latter the impact of the species may be very strong, especially if its growth is not controlled (Kamiński 2018 – A).

Eichhornia crassipes, apart from its place of origin, is considered to be the most troublesome alien aquatic species in the world, called e.g. 'a water blight' or 'a million–dollar weed' (Coetzee et al. 2017 – P). It is a clonal plant with a spectacular ability to reproduce and create large-area floating mats in a very short time. Through the growth in shipping channels and river ports, it significantly reduces shipping (Harley 1994, Kriticos and Brunel 2016 – P, EPPO 2018 – B). Many aspects of the negative influence of this species on the natural environment and economies associated with water are showed (crops and livestock). In Spain, *Eichhornia crassipes*, by blocking the canals, disturbs irrigation practices (Tellez et al. 2008 – P) or electricity generation by clogging water supplies in hydroelectric plants (Clayton and Champion 2006 – P). In many countries, eichhornia restricts access to water for human populations living around the reservoirs. Dense mats which limit the access of light, lead to the complete disappearance of underwater vegetation (Toft et al. 2003 – P), and by covering large surfaces of water reservoirs, they cause a drastic decrease in water oxygenation (to the point of total lack of oxygen) underneath them, which has catastrophic consequences for aquatic fauna, fish and fishermen (Masifwa et al. 2001, Midgley et al. 2006, Perna et al. 2011 – P); for example, in Benin, Africa, in the areas dominated by *Eichhornia crassipes*, fishing decreased by more than 50% (Harley 1994 – P). In the tropical and subtropical regions, *Eichhornia* provides a habitat for the reproduction of Mosquitoes (tropical mosquitoes) carrying the unicellular *plasmodia* that cause malaria (Kant et al. 1996 – P). There are reports in scientific literature that the species may be an indirect factor in the development of cholera. Feikin et al. (2010 – P) found a direct correlation between the reported cases of cholera between 1994 and 2008 in the province of Nyanza in Kenya bordering with Lake Victoria and the spread of *Eichhornia crassipes*.

A1 | Introduction

Questions from this module assess the risk for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation. This leads to *introduction*, defined as the entry of *the organism* to within the limits of *the area* and subsequently into the wild.

a06. The probability for ***the species*** to expand into Poland's natural environments, **as a result of self-propelled expansion** after its earlier introduction outside of the Polish territory is:

X	low
	medium
	high

aconf02. Answer provided with a

low	medium	high
		X

level of confidence

acomm06. Comments:

Tropical areas of South America (Brazil) are home of the water hyacinth. It is an expansive species, spread throughout the tropics and subtropics of all continents (CABI 2017 – B), with confirmed presence in over 50 countries (Coetzee et al. 2017 – P); it also invades the

warmer regions of the temperate zone (Kriticos and Brunel 2016, Coetzee et al. 2017 – P). In Europe, the species is established in Portugal and Spain (invasive), Italy and France (Brundu et al. 2013, Coetzee et al. 2017 – P), and its ephemeral appearance has been observed in many European countries, e.g. Belgium, Germany, the Netherlands, the United Kingdom, the Czech Republic. It was also identified in Hungary and Romania, where it was described as a non-invasive one-season plant, in the natural habitats where it was introduced (CABI 2017 – B, Coetzee et al. 2017 – P, EPPO 2018 – B). The species is quite common in garden cultivation and is sometimes used in hydrobotanical sewage treatment plants. In August 2016, The European Union has banned the sale of *Eichhornia crassipes* in order to protect the aquatic ecosystems of Spain, Portugal and southern France (Regulation... 2014 – I).

The probability of the species appearing in the natural environment of Poland as a result of independent expansion (spontaneously) is practically none (see: Kriticos and Brunel 2016 – P). This also applies to plants of the described small populations, which disappear from the territory of the Czech Republic during winter time (Pyšek et al. 2002 – P, AOPK CR 2016 – B), of which the nearest was at a distance of ca. 250 km from the Polish border (lack of water connections). Although the plant produces many long-lived seeds in a subtropical climate (Sculthorpe 1971, Gopal and Sharma 1981, Coetzee et al. 2017 – P), the predominant reproduction method is vegetative reproduction (clonal plant, Barrett 1980 a,b – P), which in principle is the only reproduction method and ensures rapid overtaking of the space in warm regions of temperate climate. For this reason, the spontaneous spread of the species is severely limited. It should also be noted that the plants are not resistant to frost and die in winter, and that the minimal threshold temperature is 0°C (CABI 2017 – P). For this reason, on national horticultural farms, summer crops are grown in open tanks and are transferred to tropical or cool greenhouses for the winter (4-10oC) period; under our climatic conditions, even in the warmest winters, survival ofthe plant has never been recorded (Kamiński 2018 – A and interviews in the horticultural farms).

a07. The probability for *the species* to be introduced into Poland's natural environments by **unintentional human actions** is:

X	low
	medium
	high

aconf03.	Answer provided with a	low	medium	high **X**	level of confidence

acomm07. Comments:

Although the species was offered on the market in Poland and is sometimes cultivated in domestic water gardens, its migration capacity, in the absence of physical connections of water reservoirs, considering vegetative reproduction, is zero. *Eichhornia crassipes* was examined in Poland for its potential use in wastewater purification and water reservoir recultivation (Kamiński 2018 – A). Plants do not reproduce generatively in our climate (Barrett 1980 a,b – P), thus there is no possibility of propagation of seeds through animals and water (zoo– and hydrochoria) or an introduction due to unintended human actions, e.g. with plant material, soil, with water equipment, etc. However, taking the possibility of accidental introduction of whole plants or their parts into the environment into account (e.g. in thermally unchanged waters), it is impossible for this species to form a long-term population in our climate. Plants are sensitive to frost and die in winter (Gąbka 2018, Kamiński 2018– A).

a08. The probability for *the species* to be introduced into Poland's natural environments by **intentional human actions** is:

X	low
	medium
	high

aconf04.	Answer provided with a	low	medium	high **X**	level of confidence

acomm08. Comments:

The species has been present in botanical greenhouses in Poland since the beginning of the 19th century. According to the survey, conducted in January of this year, Currently, *Eichhornia* is included in the collection of two botanical gardens only, i.e. in Wrocław and Poznań, and in one horticultural farm – however, it is not offered for sale (Kamiński 2018 – A, Employees of gardens... 2018 – N).

There is no information indicating that plants that are occasionally grown in the open air have survived winter periods and are resistant to frost. This species, probably introduced accidentally to the lakes with elevated water temperature near Konin, did not form permanent populations (Gąbka 2010-2017 – A). Therefore, any attempt to introduce it into open reservoirs for long-term cultivation will end in failure. However, deliberate introduction into water reservoirs seems likely, have noted, to use of water hyacinth for the purification of hypertrophic (rich in nutrients) water reservoirs is tempting – as was recorded in Spain and Italy (Brundu et al. 2013 – P) – and was also tested in our country (Gąbka 2018, Kamiński 2018, – A). It should be noted, however, that despite the bans, *Eichhornia crassipes* is still available on horticultural market (as an attractive water ornamental plant used in aquaristics and seasonal ponds in gardens), including online sales in many countries, including Poland (Coetzee et al. 2017 – P, Gąbka 2018, Kamiński 2018– A).

Plants do not reproduce generatively in our climate (Barrett 1980 a,b – P), thus there is no possibility of propagation of seeds through animals and water (zoo– and hydrochoria) or an introduction due to unintended human actions, e.g. with plant material, soil, with water equipment, etc. However, given the deliberate (e.g. with water aquaria) or the accidental introduction of whole plants or parts of plants into the environment (e.g. in thermally unchanged water conditions), it should be noted that it is not possible for this species to form a long-term population in our climate. Plants are sensitive to frost and die in winter (Gąbka 2018, Kamiński 2018– A).

A2 | Establishment

Questions from this module assess the likelihood for *the species* to overcome survival and reproduction barriers. This leads to *establishment*, defined as the growth of a population to sufficient levels such that natural extinction within *the area* becomes highly unlikely.

a09. Poland provides **climate** that is:

X	non-optimal
	sub-optimal
	optimal for establishment of *the species*

aconf05.	Answer provided with a	low	medium	high **X**	level of confidence

acomm09. Comments:

Eichhornia crassipes is a tropical species. Plants are sensitive to frost and die in the winter. However, in the narrow strip of US shoreline of the Gulf of Mexico (southern edge of Texas, Louisiana, Mississippi and Florida) in the 9-11 climate zone (freeze zones, based on the average annual minimum temperature), where the temperature of air (not water) in winter can temporarily drop to -9°C the plant can be invasive (EPPO 2018 – I). For this reason, *Eichhornia crassipes* is sometimes said to be resistant to winter but sensitive to frost. Frost kills leaves and petioles that protect shortened stems and stolons; only prolonged low temperatures below 5°C, can kill them, causing the death of the plant (Owens and Madsen 1995 – P). The geographical distribution of *Eichhornia crassipes* is currently limited by the temperatures causing the formation of ice caps in the water reservoirs and the freezing of

the soil (Grodowitz et al. 1991, Owens and Madsen 1995 – P). Kasselmann (1995 – P) states that the minimum temperature in which *Eichhornia crassipes* is able to grow is 12°C, the optimum temperature is 25-30°C and the maximum temperature is 33-35°C. These data are also confirmed by Owens and Madsen (1995 – P). The seeds may survive through unfavorable conditions which will enable the regeneration of the population when favorable conditions appear (Coetzee et al. 2017 – P). According to the latest climate change models, *Eichhornia crassipes* may spread to higher latitudes as temperatures rise (Rodriguez-Gallego et al. 2004, Rahel and Olden 2008 – P), including Europe, mainly covering the Mediterranean Sea region (Coetzee et al. 2017 – P). According to the map of comparing climatic similarity of Poland to the rest of the world, developed using the Mahalanobis's distance modelling method, the climatic conditions in Poland do not correspond to those in the area of natural occurrence of *Eichhornia crassipes* (CABI 2017 – B). This is also confirmed by the models of potential risk for the spread of this species presented in the study by Kriticos and Brunel (2016 – P). Unfavorable climatic conditions in Poland are determined by frost during which the temperature in the warmest winter regions of Poland can drop to -10°C (Szczecin) and last for several days forming a fairly thick ice coating on water reservoirs. To sum up, it should be stressed that in various climate scenarios for 2080 the species is not predicted to be present in Poland.

a10. Poland provides **habitat** that is

	non-optimal
X	sub-optimal
	optimal for establishment of *the species*

aconf06.	Answer provided with a	low	medium	high **X**	level of confidence

acomm10. Comments:

The fast-growing plants of *Eichhornia crassipes* prefer eutrophic and hypertrophic waters rich in nitrogen, phosphorus and potassium, in which they also find very good conditions for seed sprouting (Labrada et al. 1994, Albano Pérez et al. 2011 – P). The species prefers pH-neutral waters but tolerates a pH range between 4-10; it tolerates mild salinity (Coetzee et al. 2017 – P). In its natural range, *Eichhornia crassipes* grows near rivers (mainly free-flowing) and freshwater reservoirs but it also grows as weed on rice fields (CABI 2017 – B). In the European part of the secondary range of the species (Portugal, Spain, Italy) the water hyacinth spreads nearby slowly-flowing rivers, lagoons and swamps (Coetzee et al. 2017 – P).

Such shallow reservoirs, which are warm in summer and rich in nutrients, are common in Poland. After breaking the climate barrier in Poland, the species would find a convenient place first in 'thermally polluted' reservoirs with elevated water temperatures, and this would become a starting point for further expansion. The presence of the species in warm waters of Russia and Germany was confirmed (Hussner and Lösch 2005 – P). Other conditions ensuring the survival and reproduction of the species (apart from temperature) are also potentially fulfilled. Although in the secondary range the plant mainly reproduces vegetatively, generative reproduction is theoretically possible. The plant blooms in temperature of ca. 20°C, and its flowers are self-pollinating or pollinated by insects. The main insect pollinating the flowers of *Eichhornia crassipes* are *Ancyloscelis gigas* bees, while in the secondary in scope, including Europe, this role is played by *Apis melifera* honey bee (Barret 1980b, Ruiz Téllez i in. 2008 – P). In Europe, on the Iberian Peninsula, plants bloom from June to October, while fruits ripen by November. Nevertheless, the limited presence of pollinators and unfavorable conditions for seed sprouting and survival (Barret 1980b – P) are considered to be limiting factors for generative reproduction in the secondary range. One the most important factors limiting the effectiveness of establishment of the species in Poland are winter temperatures (freezing of water reservoirs).

A3 | Spread

Questions from this module assess the risk of *the species* to overcoming dispersal barriers and (new) environmental barriers within Poland. This would lead to spread, in which vacant patches of suitable habitat become increasingly occupied from (an) already-established population(s) within Poland.

Note that spread is considered to be different from range expansions that stem from new introductions (covered by the Introduction module).

a11. The capacity of *the species* to disperse within Poland by natural means, **with no human assistance**, is:

	very low
X	low
	medium
	high
	very high

aconf07.	Answer provided with a	low	medium	high **X**	level of confidence

acomm11. Comments:

Eichhornia crassipes is a perennial plant that floats on water, it reproduces both vegetatively through organ fragmentation, and generatively through seeds (Coetzee et al. 2017 – P). Rapidly growing seedlings and seeds produced in large quantities can be transported with water current during floods. Animals such as birds and mammals (e.g. hippopotamus) are also involved in spreading diaspores of the species. Theycan help the spread of the plant over long distances (Coetzee et al. 2017 – P).

Type A data – dispersion from a single source:
Data on the history of the introduction and spread of the species in different parts of the world provide evidence of its very high spreading potential without human intervention. One example is the spectacular invasion of the St. John River in Florida in 1895, when strong gusts of wind spread diaspores (vegetative fragments of plants) over a 160km-long section of the river, which lead to formation of floating water hyacinth mats measuring up to 40 km in length (Coetzee et al. 2017 – P). In the European part of the secondary range, the rate of spread is slower: the species was confirmed in 2005 in the 75 km section of the Guadiana River in the south-west of the Iberian Peninsula, and reached the Spanish-Portuguese border after 10 years (Ruiz Téllez et al. 2008, 2016 – P).

Data concerning the assessment of the biological mobility of the species (type C):
Eichhornia crassipes is locally spread throughout the secondary range mainly by vegetative reproduction. Under favorable conditions (nutrient availability, temperature), population sizes can double in two weeks (Edwards and Musil 1975 – P); this ability of the plant has also been confirmed experimentally (Ruiz Téllez et al. 2008 – P). At sites in the Guadiana River (Spain), the population doubled over a period of 10-60 days (Ruiz Téllez et al. 2008 – P); Gopal (1987 – P) specifies two ranges – covering the following periods: 5.9-28.1 days or 3.7-57.8 days, depending on the conditions. *Eichhornia crassipes* is also characterized by a high potential for generative reproduction. Fast-growing plants bloom just 10-15 weeks after sprouting. Barrett (1980b – P) states that a plant inflorescence with 20 flowers can produce more than 3,000 seeds, while a plant rosette can produce up to 4 inflorescences in 21 days. In favourable conditions, the seeds sprout immediately; at the same time, they retain their sprouting capacity for many years (Gopal 1987 – P). The estimated number of seeds per m^2 of vegetation ranges from 400 to 3400 (Pieterse and Murphy 1993, Cronk and Fennessy 2001 – P). The species forms a long-term seed bank with a life span of up to 20 years (Gopal 1987 – P) which has a size of 0 to 2534 seeds/m^2. The results of the research by soil seed bank indicate a significant influence of factors such as water level fluctuations, eutrophication and seed death on the possibility of survival and spread of the species (Coetzee et al. 2017 – P).

Observations of water hyacinth cultivation in water reservoirs in the open area of Wrocław's botanical garden and horticultural farm in Gorzyck Stary indicate relatively slow vegetative reproduction of this species in our climate; one mother plant produces several

newcomers covering an area of ca. 1 m^2. This was confirmed by Pyšek et al. (2002 – P) referring to small populations (up to several dozen of plants) found on natural sites in the Czech Republic. Thus, the real dispersion from a single source (type A data) in this part of Europe is very limited. It can be assumed that a cluster of plants thrown into Oder river in Wrocław during the vegetation season will reach Szczecin covering a distance of several hundred kilometres, but this should not be associated with the effect of settlement and establishment in new habitat conditions. In such case, it is difficult to discuss a large dispersion and expansion of the population which will be finished by the first winter. Modelled climate scenarios do not predict the spread of this species in the country even by 2080 (Kriticos and Brunel 2016 – P).

The final result of the assessment is determined by the lack of generative reproduction in temperate climates and by the fact that *Eichhornia crassipes* is not resistant to frost, that eliminates plants in winter (Kamiński 2018 – A). In Poland, there were no long-term populations in the natural environment (Kamiński 2018, Gąbka 2018 – A).

a12. The frequency of the dispersal of *the species* within Poland by **human actions** is:

X	low
	medium
	high

aconf08. Answer provided with a

low	medium	high	level of confidence
		X	

acomm12. Comments:

Despite the knowledge gathered about the invasive potential of *Eichhornia crassipes*, the main role in its spread is still played by the humans who continue to grow the plant (horticulture) and use it in aquaristics, mainly because of the attractive flowers (appearance and smell) (Coetzee et al. 2017 – P). Therefore, the intentional spread of this species by humans cannot be excluded (e.g. online sales for cultivation as an ornamental plant, followed by 'escape' or 'release' of the species into the wild). In the areas where it is found, humans are also involved in the further, most often unintended, spread of plants with floating equipment and during fishing (Coetzee et al. 2017 – P).

In Poland, no annual or perennial population was found to grow under natural conditions (excluding thermally modified waters). Therefore, there is no spread of the species to new areas. The species is grown in botanical gardens, horticultural farms (nurseries) for commercial purposes and is sometimes imported from subtropical regions by businesses. Thus, exchange (from one garden to another) and trade are the only means of spreading the species; however, this is not the case outside the closed areas (Kamiński 2018, Gąbka 2018 – A). Accidental or even deliberate planting of *Eichhornia crassipes* in natural reservoirs will be limited to short-term growth in the vegetation period, and to the extinction of the plants in winter. The lack of generative reproduction secures its development in the new growing season.

A4a | Impact on the environmental domain

Questions from this module qualify the consequences of *the species* on wild animals and plants, habitats and ecosystems.

Impacts are linked to the conservation concern of targets. Native species that are of conservation concern refer to keystone species, protected and/or threatened species. See, for example, Red Lists, protected species lists, or Annex II of the 92/43/EWG Directive. Ecosystems that are of conservation concern refer to natural systems that are the habitat of many threatened species. These include natural forests, dry grasslands, natural rock outcrops, sand dunes, heathlands, peat bogs, marshes, rivers & ponds that have natural banks, and estuaries (Annex I of the 92/43/EWG Directive).

Native species population declines are considered at a local scale: limited decline is considered as a (mere) drop in numbers; severe decline is considered as (near) extinction. Similarly, limited ecosystem change is considered as transient and easily reversible; severe change is considered as persistent and hardly reversible.

a13. The effect of *the species* on native species, through **predation, parasitism or herbivory is**:

X	inapplicable
	low
	medium
	high

aconf09.	Answer provided with a	low	medium	high	level of confidence

acomm13. Comments:

Plant species – does not show such effects.

a14. The effect of *the species* on native species, through **competition** is:

	low
X	medium
	high

aconf10.	Answer provided with a	low	medium	high **X**	level of confidence

acomm14. Comments:

Species has no impact on native species of the natural environment of Poland, as the species in question is not present in it.

Assuming that E. crassipes appears in the natural environment of Poland and survives unfavourable climatic conditions (which is impossible), its influence should be assessed as high (see: data on the effects of expansion in other subtropical countries, Gopal and Sharma 1981, Toft et al. 2003, Albano Pérez et al. 2011, Brundu et al. 2015 – P).

It is not so in case of domestic crops grown outdoors, for example. Here, in the summer, especially during the warmer part of the season, the species' influence on other aquatic species is very strong. Failure to control the expansive reproduction of water hyacinth and rapid plant growth result in ousting of floating plants and almost complete extinction of submarine plants (Kamiński 2018, Gąbka 2018 – A).

In warm climate zones, the species is able to form dense, single-species aggregations, often covering large surface of watercourses and reservoirs, etc., displacing native species and contributing to a decline in the diversity of taxonomic aquatic plants (Coetzee et al. 2017 – P, EPPO 2018 – B).

a15. The effect of *the species* on native species, through **interbreeding** is:

X	no / very low
	low
	medium
	high
	very high

aconf11.	Answer provided with a	low	medium	high **X**	level of confidence

acomm15. Comments:

Lack of related species in Polish flora (Kamiński 2018, Gąbka 2018 – A).

a16. The effect of *the species* on native species by **hosting pathogens or parasites** that are harmful to them is:

	very low
	low
X	medium
	high
	very high

aconf12.	Answer provided with a	low	medium	high **X**	level of confidence

acomm16. Comments:

Studies by Patoki et al. show (2016 – P) many pathogens are imported into the environment together with the imported *Eichhornia crassipes* plants regardless of whether they are grown indoors (greenhouses) or outdoors (gardens). Unfortunately, as yet there is no complete information on which of them can survive our winters, and therefore be invasive, nor on which of them can be harmful to the native species. Freshwater snails found in plants are related to species that have been registered as invasive in Europe. This situation may therefore be a cause for concern, as the snails are transferred with the water hyacinths directly to the garden ponds and are therefore likely to spread to new areas. The species with the highest invasive potential, whose presence was confirmed in the imported plants, is the Indo-Australian moth of *Spodoptera litura* (Fabricius), which tolerates temperature drops to 10°C and has already been recorded in Europe, from Great Britain to Russia. During the first period of its invasion, it caused serious damage to crops (clover, corn, tomatoes, cauliflowers, etc.) in several regions almost all its sites have been deleted.

a17. The effect of *the species* on ecosystem integrity, by **affecting its abiotic properties** is:

	low
X	medium
	high

aconf13.	Answer provided with a	low	medium	high **X**	level of confidence

acomm17. Comments:

Assuming that the species spreads across Poland, its impact on abiotic factors of aquatic ecosystems may be significant in two ways:

1. assuming that the growing plants are removed outside the water reservoirs, excessive nutrients and metals would be removed from the aquatic ecosystem (Labrada et al. 1994 – P);
2. without removing the accumulated plants (which is more likely), the introduction of an additional portion of biomass into fertile habitats, which will start to rot, leading to a complete loss of oxygen and, as a result, rapid degradation of these habitats and their rapid disappearance due to accelerated succession (Gąbka 2018, Kamiński 2018 – A).

Water hyacinth worsens light conditions (light climate) in tanks and watercourses; it reduces gas exchange and accelerates unfavorable anaerobic processes (CABI 2017 – B).

a18. The effect of *the species* on ecosystem integrity, by **affecting its biotic properties** is:

	low
X	medium
	high

aconf14.	Answer provided with a	low	medium	high **X**	level of confidence

acomm18. Comments:

Assuming that the species is spreading across Poland, its influence on the ecosystem integrity through disturbance of its biotic factors should be assessed as medium. The

species prefers strongly eutrophic and hypertrophic habitats, which are naturally already heavily relegated. The development of water hyacinth may impoverish their flora (Toft et al. 2003 – P) and fauna, including the diversity of benthic invertebrates (Midgley et al. 2006 – P), plankton (Masifwa et al. 2001 – P), however, the removal of the plant from the habitat should lead to restoring its previous condition over time. Such behavior of ecosystems was observed in the case of excessive expansion of native *Statiotes aloides* and *Salvinia* (Kamiński 2018 – A).

A4b | Impact on the cultivated plants domain

Questions from this module qualify the consequences of *the species* for cultivated plants (e.g. crops, pastures, horticultural stock).

For the questions from this module, consequence is considered 'low' when presence of *the species* in (or on) a population of target plants is sporadic and/or causes little damage. Harm is considered 'medium' when *the organism's* development causes local yield (or plant) losses below 20%, and 'high' when losses range >20%.

a19. The effect of *the species* on cultivated plant targets through **herbivory or parasitism** is:

	inapplicable
X	very low
	low
	medium
	high
	very high

aconf15.	Answer provided with a	low	medium	high **X**	level of confidence

acomm19. Comments:

Species of a non-parasitic water plant.

a20. The effect of *the species* on cultivated plant targets through **competition** is:

	inapplicable
X	very low
	low
	medium
	high
	very high

aconf16.	Answer provided with a	low	medium	high **X**	level of confidence

acomm20. Comments:

The problem does not currently concern the European part of the secondary range of the species. In subtropical countries where rice is grown, *Eichhornia crassipes* is an undesirable weed that is removed from the rice fields. In extreme cases, the rice fields were abandoned due to insufficient monitoring and control (CABI 2017 – B). Assuming a substantial warming of the domestic climate and the introduction of rice crops, the spreading species would compete with the crop. Given its easy removal, supported with easy identification at early stages of the expansion and reproduction on agricultural fields, the impact should be assessed as very small. The species inhabits water reservoirs – in Poland aquatic or swamp plants are not cultivated, so there is no interaction with plant cultivation.

a21. The effect of *the species* on cultivated plant targets through **interbreeding** with related species, including the plants themselves is:

	inapplicable
X	no / very low
	low
	medium
	high
	very high

aconf17.	Answer provided with a	low	medium	high **X**	level of confidence

acomm21. Comments:

There are no related species in Poland.

a22. The effect of *the species* on cultivated plant targets by **affecting the cultivation system's integrity** is:

X	very low
	low
	medium
	high
	very high

aconf18.	Answer provided with a	low	medium	high **X**	level of confidence

acomm22. Comments:

In Spain, *Eichhornia crassipes*, by blocking the canals, disturbs irrigation practices (Ruiz Téllez et al. 2008 – P). In Poland, irrigation is less important. It can be expected that due to the less favorable climatic conditions in this country, the populations that can be established in spring (?) will not grow to the extent of those in Spain in the short summer period.

a23. The effect of *the species* on cultivated plant targets by hosting **pathogens or parasites** that are harmful to them is:

	very low
	low
X	medium
	high
	very high

aconf19.	Answer provided with a	low	medium	high **X**	level of confidence

acomm23. Comments:

Freshwater snails found in plants imported from subtropical Asia are related to species that have been registered as invasive in Europe. This situation may therefore be a cause for concern, as the snails are transferred with the water hyacinths directly to the garden ponds and are therefore likely to spread to new areas. The species with the highest invasive potential, whose presence was confirmed in the imported plants, is the Indo-Australian moth of *Spodoptera litura* Fabricius, which tolerates temperature drops to 10°C and has already been recorded in Europe, from Great Britain to Russia. During the first period of its invasion, it caused serious damage to crops (clover, corn, tomatoes, cauliflowers, etc.) in several regions almost all its sites have been deleted (Patoka et al. 2016 – P).

A4c | Impact on the domesticated animals domain

Questions from this module qualify the consequences of *the organism* on domesticated animals (e.g. production animals, companion animals). It deals with both the well-being of individual animals and the productivity of animal populations.

a24. The effect of *the species* on individual animal health or animal production, through **predation or parasitism** is:

X	inapplicable
	very low
	low
	medium
	high
	very high

aconf20.	Answer provided with a	low	medium	high	level of confidence

acomm24. Comments:

Species is a plant.

a25. The effect of *the species* on individual animal health or animal production, by having properties that are hazardous upon **contact**, is:

X	very low
	low
	medium
	high
	very high

aconf21.	Answer provided with a	low	medium	high **X**	level of confidence

acomm25. Comments:

There is no evidence that *Eichhornia crassipes* has biological, physical and/or chemical properties which are harmful in contact with livestock and pets or to livestock production (e.g. toxins or allergens).

a26. The effect of *the species* on individual animal health or animal production, by hosting **pathogens or parasites** that are harmful to them, is:

X	inapplicable
	very low
	low
	medium
	high
	very high

aconf22.	Answer provided with a	low	medium	high	level of confidence

acomm26. Comments:

No reports on transmission of pathogens or parasites harmful to plants or animals by water hyacinth.

A4d | Impact on the human domain

Questions from this module qualify the consequences of *the organism* on humans. It deals with human health, being defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (definition adopted from the World Health Organization).

a27. The effect of *the species* on human health through **parasitism** is:

X	inapplicable
	very low
	low
	medium
	high
	vert high

aconf23.	Answer provided with a	low	medium	high	level of confidence

acomm27. Comments:

A species of a non-parasitic plant.

a28. The effect of *the species* on human health, by having properties that are hazardous upon **contact**, is:

	very low
X	low
	medium
	high
	very high

aconf24.	Answer provided with a	low	medium **X**	high	level of confidence

acomm28. Comments:

There is no evidence to show that *Eichhornia crassipes* has harmful properties for humans which are revealed by direct contact.

However, the biological properties of the species can be linked to its impact on the physical and mental well-being of humans. In the tropics, large populations of the species host venomous snakes, crocodiles and hippos, making water collection dangerous and sometimes even fatal (Coetzee et al. 2017 – P and the literature quoted there).

a29. The effect of *the species* on human health, by hosting **pathogens or parasites** that are harmful to humans, is:

X	inapplicable
	very low
	low
	medium
	high
	very high

aconf25.	Answer provided with a	low	medium	high	level of confidence

acomm29. Comments:

To an underestimated extent, in warm climates some naturalised and invasive plants increase the likelihood of human health being endangered by enabling contact with pathogenic agents. Dense, floating mats of *Eichhornia crassipes* (water hyacinth) provide a perfect habitat for the reproduction of Mosquitoes (tropical mosquitoes) carrying the unicellular (*Plasmodia*) that cause malaria (Kant et al. 1996 – P). At the same time, it should be remembered that the same conditions in Poland are created by communities of native species forming floating plant mats (*Statiotes aloides*, *Hydrocharis morsus-ranae* and

Salvinia natans). There are reports in scientific literature that the water hyacinth may be an indirect factor in the development of cholera. Feikin et al. (2010 – P) found a direct correlation between the reported cases of cholera between 1994 and 2008 in the province of Nyanza in Kenya bordering with Lake Victoria and the spread of *E. crassipes*. The two rises in cholera cases in the province of Nyanza coincided with two periods of water hyacinth abundance (1997-2000 and 2006-2008). At the same time, the researchers suggested that fibrous roots of water hyacinth could be used as storage facilities for cholera bacteria, which was supported by experimental evidence (Spira et al. 1981 – P). It should be noted that Mailu (2001 – P) was not able to demonstrate such a correlation despite having similar data at his disposal. However, the question arises whether the issue is connected only with *Eichhornia*. Perhaps other aquatic plants can play such a role; it is a valid question since cholera pandemics have occurred in the past in our climate. Following the instructions: "Given the assumption that the species is spreading across Poland, the frequency (probability) of direct contact with humans and the associated effects should be estimated" the response should indicate that the species has a significant impact on human health. Referring to remarks to question a08, we believe that the real impact of the species would not be greater than that of our native species, and bearing in mind that the species is not spreading in our climate, we assess its impact as small. The more so, because the instruction states that plants are not hosts nor vectors of human pathogens/parasites.

A4e | Impact on other domains

Questions from this module qualify the consequences of *the species* on targets not considered in modules A4a-d.

a30. The effect of *the species* on causing damage to **infrastructure** is:

	very low
X	low
	medium
	high
	very high

aconf26. Answer provided with a

low	medium	high	level of confidence
		X	

acomm30. Comments:

In the current climatic conditions present in Poland (and the neighboring countries), no influence of the species on the infrastructure is observed.

If Eichhornia was to occur in the environment, its only negative effect on the infrastructure would be blocking the small watercourses and ducts, but the influence would be periodical (concerning one-year period) and completely reversible (Kamiński 2018 – A).

However, assuming that the climate becomes similar to Mediterranean (which may happen by the end of the century), the negative effect of the species on infrastructure will increase. Here, the current data for the Mediterranean countries (Italy, Spain, Portugal, France) can be referred to. The species has proven to be fairly invasive in the south-western areas of the Iberian Peninsula, where the influence of the warm Atlantic is significant during the winter and sometimes the plants are able to winter. Here, over the course of two years, the plants were able to control over approx. 200 ha of bays on a 75-km long stretch of the Guadiana River (Tellez et al. 2008 – P). In colder Italy, the invasiveness of the species is much lower; here the 'invasion' of Eichhornia has started 140 years ago and the plants were recently observed in two sites (Brundu et al. 2013 – P). Taking this into account, it can be assumed that in the future the influence of the species on all infrastructure in Poland will be small (considering the climate limitations).

It is not so in countries with a warm climate.

In addition to the influence of Eichhornia crassipes on biodiversity, the socioeconomic impact of the species has also been documented, including its impact on infrastructure

(Coetzee et al. 2017 – P). The thick layers formed by fast-growing plants block natural and anthropogenic watercourses, restricting access to water, hindering navigation, the efficiency of irrigation channels and hydropower programmes (contributing to clogging and corrosion of the turbines). In some African countries, interruption in electricity production and supply have been estimated to cost several hundred thousand to several million dollars annually (Coetzee et al. 2017 – P, and the literature quoted there). Other problems include damage to property during floods due to the accumulation of large plant biomass on bridges, fences, etc., which prevents the drainage of water and leads to an increase in water levels. The Eichhornia crassipes invasion undoubtedly changes the living conditions of local communities depending on the availability and status of water resources (African reports), but the possible associated costs have not yet been estimated (Coetzee et al. 2017 – P).

A5a | Impact on ecosystem services

Questions from this module qualify the consequences of *the organism* on ecosystem services. Ecosystem services are classified according to the Common International Classification of Ecosystem Services, which also includes many examples (CICES Version 4.3). Note that the answers to these questions are not used in the calculation of the overall risk score (which deals with ecosystems in a different way), but can be considered when decisions are made about management of *the species*.

a31. The effect of *the species* on **provisioning services** is:

	significantly negative
X	moderately negative
	neutral
	moderately positive
	significantly positive

aconf27.	Answer provided with a	low	medium	high **X**	level of confidence

acomm31. Comments:

The biology of the species and its habitat requirements indicate that it remains neutral – it has no influence on supply services, such as food, materials and power supplies (Gąbka 2018, Kamiński 2018 – A).

Theoretically, only the mass development of water hyacinth, e.g. in dammed reservoirs, etc. may complicate the collection of the supplies of drinking water and water for other purposes and adversely affect infrastructure designed for water collection (EPPO 2018, CABI 2017, CIRCABAC 2018 – B). It is therefore not a mistake to assume that the species has little or no influence, given its rareness, and this influence can be assessed as moderately negative.

a32. The effect of *the species* on **regulation and maintenance services** is:

	significantly negative
	moderately negative
	neutral
X	moderately positive
	significantly positive

aconf28.	Answer provided with a	low	medium	high **X**	level of confidence

acomm32. Comments:

On a micro scale, the positive effects associated with e.g. local purification of hypertrophic water and polluted wastewater would be neutralized by the negative influence of the

species on native flora and fauna, etc. A deterioration of water quality due to intensified eutrophication processes in the case of large-scale population extinction cannot be excluded either (Gąbka 2018, Kaminski 2018 – A); based on the literature mentioned earlier. However, taking the comment on section a30 (estimation of the limited invasion of *E. crassipes* in Poland) into account and considering the possible use of *Eichhornia* for urban wastewater purification in closed plants and subsequent plant composting (end result – biowaste), it can be assumed that the impact of the species on regulatory services may be moderately positive (Gąbka 2018, Kamiński 2018 – A). Practical use of this species in wastewater treatment was also introduced in Poland.

a33. The effect of *the species* on **cultural services** is:

	significantly negative
	moderately negative
	neutral
X	moderately positive
	significantly positive

aconf29.	Answer provided with a	low	medium	high **X**	level of confidence

acomm33. Comments:

The species does not affect cultural services as science, education, spiritual sphere or artistic resources. Cultivation only makes the garden ponds more attractive (Kamiński 2018 – A).

A5b | Effect of climate change on the risk assessment of the negative impact of *the species*

Below, each of the Harmonia^{+PL} modules is revisited under the premise of the future climate. The proposed time horizon is the mid-21st century. We suggest taking into account the reports of the Intergovernmental Panel on Climate Change. Specifically, the expected changes in atmospheric variables listed in its 2013 report on the physical science basis may be used for this purpose. The global temperature is expected to rise by 1 to 2°C by 2046-2065.

Note that the answers to these questions are not used in the calculation of the overall risk score, but can be but can be considered when decisions are made about management of *the species*.

a34. INTRODUCTION – Due to climate change, the probability for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf30.	Answer provided with a	low	medium **X**	high	level of confidence

acomm34. Comments:

The current climatic conditions in Poland are significantly different from those in the region of origin of Eichhornia crassipes (South America) and are not optimal for the development of the species. The assumed increase of the average temperature in Poland by 1-2oC will not affect the current barriers limiting its development and expansion in Poland significantly, except for the increase of its growth rate.

a35. ESTABLISHMENT – Due to climate change, the probability for *the species* to overcome barriers that have prevented its survival and reproduction in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf31.	Answer provided with a	low	medium **X**	high	level of confidence

acomm35. Comments:

The seasonal occurrence and presence of the species during periods of warmer multiannual temperature amplitudes cannot however be regarded as a permanent establishment of the species (Kamiński, Gąbka 2018– A), however it cannot be excluded that its resistance to lower temperatures will increase.

a36. SPREAD – Due to climate change, the probability for *the species* to overcome barriers that have prevented its spread in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf32.	Answer provided with a	low	medium **X**	high	level of confidence

acomm36. Comments:

Assuming that temperatures rise slightly and that the species evolves to become more resistant to lower temperatures, it can be assumed that the probability of seasonal spread in the long term may also increase, especially in regions with more favorable conditions (see commentary to questions a34, a35).

a37. IMPACT ON THE ENVIRONMENTAL DOMAIN – Due to climate change, the consequences of *the species* on wild animals and plants, habitats and ecosystems in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf33.	Answer provided with a	low	medium	high **X**	level of confidence

acomm37. Comments:

If the average temperature rises by 1-2oC, its effect on the natural environment will not change much. Assuming that *Eichhornia crassipes* is introduced to the natural environment of Poland as a result of climate change, its influence will increase moderately (see: data describing the effects of expansion in other subtropical countries; Gopal and Sharma 1981, Toft et al. 2003, Albano Pérez et al. 2011, Brundu et al. 2015 – P and comment to question a14).

a38. IMPACT ON THE CULTIVATED PLANTS DOMAIN – Due to climate change, the consequences of *the species* on cultivated plants and plant domain in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf34.	Answer provided with a	low	medium **X**	high	level of confidence

acomm38. Comments:

With a slight increase of the average annual temperature, the impact of the species on crops and crop production will remain the same. The species does not affect plant production in Poland due to its specific nature (only land cultivation of seed plants, see question a20).

However, it cannot be excluded that with a greater increase of the average temperature, the likelihood of occurrence of the species in Poland will increase and the risk of spreading plant pathogens will also increase (see question a23). It is also possible to impede the flow of water in drainage channels, but in Poland it may be of local importance (see question a22).

a39. IMPACT ON THE DOMESTICATED ANIMALS DOMAIN – Due to climate change, the consequences of *the species* on domesticated animals and animal production in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf35.	Answer provided with a	low	medium **X**	high	level of confidence

acomm39. Comments:

The species has no influence on animal farming, except for fishing, so the predicted climate change will only cause such changes.

If the current status quo of the species in the Polish flora remains the same, the influence of the species on humans will not change.

a40. IMPACT ON THE HUMAN DOMAIN – Due to climate change, the consequences of *the species* on human in Poland will:

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf36.	Answer provided with a	low	medium	high **X**	level of confidence

acomm40. Comments:

See section 29.

a41. IMPACT ON OTHER DOMAINS – Due to climate change, the consequences of *the species* on other domains in Poland will:

	decrease significantly
	decrease moderately

	not change
X	increase moderately
	increase significantly

aconf37.	Answer provided with a	low	medium	high X	level of confidence

acomm41. Comments:

If the average temperature rises by 1-2oC, its effect (or rather the lack of it) on the natural environment will not change much.

However, assuming that the climate becomes similar to Mediterranean (which may happen by the end of this century), the negative impact of *Eichhornia crassipes* on infrastructure will increase moderately. Here, the data currently available for the Mediterranean countries (Italy, Spain, Portugal, France) can be referred to. The invasive character of the species was noted in the south-western areas of the Iberian Peninsula, where the influence of the warm Atlantic is significant in winter and where sometimes the plants are able to winter. In the course of two years, the plants were able to control approx. 200 ha of bays on a 75km-long stretch of the Guadiana River (Ruiz Téllez et al. 2008 – P). In colder Italy, the invasiveness of the species is much lower; here the 'invasion' of Eichhornia started 140 years ago and has recently been observed in two sites (Brundu et al. 2013 – P). Taking this into account, it can be assumed that in the future the impact of the species on the infrastructure on the territory of Poland will still be small (taking climate limitations into account), however, possible overcoming of climate barriers would be associated with a significant impact of the species on the infrastructure and large economic losses, which are already observed in the warmer regions of Europe (e.g. Wittmann and Flores-Ferrer 2015 – P).

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	0.00	1.00
Establishment (questions: a09-a10)	0.25	1.00
Spread (questions: a11-a12)	0.13	1.00
Environmental impact (questions: a13-a18)	0.40	1.00
Cultivated plants impact (questions: a19-a23)	0.10	1.00
Domesticated animals impact (questions: a24-a26)	0.00	1.00
Human impact (questions: a27-a29)	0.25	0.50
Other impact (questions: a30)	0.25	1.00
Invasion (questions: a06-a12)	0.13	1.00
Impact (questions: a13-a30)	0.40	0.90
Overall risk score	0.05	
Category of invasiveness	potentially invasive alien species	

A6 | Comments

This assessment is based on information available at the time of its completion. It has to be taken into account. However, that biological invasions are, by definition, very dynamic and unpredictable. This unpredictability includes assessing the consequences of introductions of new alien species and detecting their negative impact. As

a result, the assessment of the species may change in time. For this reason it is recommended that it regularly repeated.

acomm42. Comments:

Water hyacinth (*Eichhornia crassipes*) should be classified as a non-invasive species in our climate. Although for several decades it has been grown in botanical garden greenhouses (currently only in the gardens in Poznań and Wrocław) and has been imported for commercial purposes (cultivation in garden ponds), so far there is no information about the survival during the winter periods or finding the species in the natural environment. Its spread capacity is low due to its vegetative reproduction, which is the only possibility in our climate, and there is no evidence of generative reproduction in glasshouse cultivation either. The species is sensitive to low temperatures, the plants stop growing when the temperature is lower than 5 (10?)°C and each freezing of the plants leads to its death. In other European countries with similar climates, no negative effects have been observed either. The study by Kriticos and Brunel (2016 – P) shows the climate predictions and risk analysis of the global expansion of *E. crassipes*, with a strong potential of the future expansion in Europe. It should be stressed that in various climate scenarios for 2080, *E. crassipes* is not predicted to be present in Poland.

It should be noted that the import and trade of this species was recently banned due to its inclusion in the Polish and European legislation on invasive foreign species. Therefore, the risk of introduction and its establishment of *E. crassipes* in the future in Poland is low.

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