Chapter 6

General discussion

The aim of this thesis was to investigate whether and to what extent characteristics of the study context play a role in the estimation of monetary values for water-related ecosystem services. In particular, it was investigated whether the role of the ecological status of the ecosystem that produces the services is consistently reflected in ecosystem service values. If that is the case, estimated monetary values for water-related services can serve a tool to incorporate environmental effects in policy and decision-making.

In order to account for the different aspects of study context, various characteristics of ecosystem service delivery were differentiated among, being the capacity side of ecosystem service production (ecosystem factors), the demand side of ecosystem service use by beneficiaries (beneficiary factors) and the flow of ecosystem services between providing and benefitting areas (spatial factors). In addition, possible effects of the selected methodological approach on estimated monetary values were controlled for (methodological factors). The effect sizes of each these factors of the study context and selected methodology were explicitly quantified in order to assess the validity of monetary valuation.

The extent to which the various factors determine ecosystem service valuation was investigated for two types of water-related ecosystem services in two different regions: water quantity-related services specifically in regions that experience water scarcity (i.e. drylands; chapters 2 and 3) and water quality-related services in a region that faces water quality challenges (i.e. the Scheldt river basin; chapters 4 and 5).

Different methodological approaches were applied. For water quantity-related services, a meta-analysis was conducted using more than 500 estimates from case studies worldwide, including a wide range of ecosystem service valuation methods (chapters 2 and 3). In chapter 2, relevant variables identifying the dryland study context were taken into account, including ecosystem and beneficiary factors, while controlling for variation in the selected valuation approach (methodological factors). In addition, chapter 3 provides an in-depth analysis of the variation in monetary values estimated by different methods and provided by different dryland ecosystem types. Chapters 4 and 5 zoom in on the willingness to pay (WTP) valuation method to analyze monetary values that are estimated for water quality-related ecosystem services. A dichotomous choice and open-ended WTP were investigated using regression analysis. In chapter 4, the role of ecosystem and spatial factors were analyzed in determining value estimations, in addition to beneficiary factors and along with controlling for methodological

factors. Chapter 5 examines how preferences for water quality improvements are affected by perceptions of water quality.

From these various analyses, four main trends in the estimation of monetary values for water-related ecosystem services emerged. Three of the trends relate to monetary valuation and concern (1) the effects of beneficiary factors, (2) the marginal role of the ecosystem and spatial factors, and (3) the dominant role of methodological factors. The last trend concerns the limited comprehension of ecosystem service benefits by beneficiaries. These four trends are discussed below. This is followed by a discussion of the implications of these findings for society and policy, environmental management and science. After that, ways forward for future research are formulated. Finally, the conclusion of this thesis is summarized.

6.1 Main trends

First, the characteristics of the study context and methodology influencing monetary valuation are discussed, starting with the beneficiary factors, followed by the ecosystem and spatial factors, and ending with the methodological factors (Figure 6.1).

6.1.1 Effects of beneficiary factors

In line with previous research, it is found that beneficiary factors are of some relevance in the monetary valuation of both types of water-related services in varying ways (Figure 6.1). For water quantity-related services, socio-economic conditions that were analyzed included regional GDP per capita, regional population density, land use types and land use intensity (chapter 2). While GDP and population density did not have any effect, land use intensity and in particularly land use types significantly affected estimated values for water quantity-related services (38% of the explained variation), possibly because land use opportunities are constrained by limited water availability in drylands.

For water quality-related ecosystem services, the role of multiple beneficiary factors for socio-economic and personal characteristics was investigated. Some of the socio-economic characteristics, including income and region of residence, were found to affect estimated monetary values, having medium to large effects (chapter 4). Also, several personal characteristics, including how people perceived the credibility of the policy measure, how clear they found the WTP question and how they felt about not reaching good water quality, played some role in explaining variation in estimated values (having small to medium effect sizes). Together, these findings show that beneficiary factors play a role in the monetary valuation of water-related services. This is not surprising in light of previous studies, which also found that specific socio-economic conditions of beneficiaries play a role in the monetary valuation of ecosystem services (e.g. Genius et al., 2008; Ghermandi et al., 2010; Quintas-Soriano et al., 2016).

6.1.2 Ecosystem and spatial factors neglected in ecosystem services valuation

More remarkable is that the role of ecosystem and spatial factors was found to be of minor importance in the monetary value estimation of both water quantity- and water quality-related ecosystem services (see Figure 6.1). For *water quantity-related services* in drylands,

specifically relevant ecosystem factors for the dryland study context were analyzed (chapter 2). These included indicators for water availability, vegetation cover and productivity, and soil conditions. As only water availability and soil acidity explained a very small amount of variation in estimated monetary values (less than 1% of the total explained variation in both regression models, that explained between 27 – 39% of the variation in the data), these ecosystem factors were found to be of minor importance in explaining variation among estimated values for water quantity-related services. At the same time, methodological factors explained most variation in this analysis (around 80% in the regression model with valuation method).

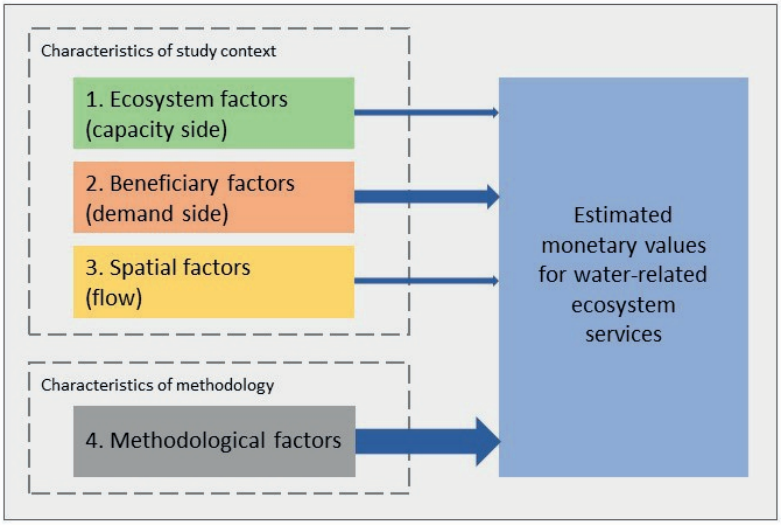

Figure 6.1 The contribution of characteristics of the study context: (1) ecosystem, (2) beneficiary and (3) spatial factors, and characteristics of the methodology: (4) methodological factors to the explained variation in estimated monetary values for water-related ecosystem services, as indicated by the width of the arrows.

In comparison with these ecosystem factors that indicated specific ecosystem conditions, factors that reflected characteristics of the ecosystem in a much broader sense – by differentiating between dryland ecosystem types, being semi-deserts, grasslands, woodlands, dry forests, arid wetlands and cultivated lands – were found to have some impact on estimated values for water quantity-related services (30% of the explained variation; chapter 2). Specifically, differences were found between estimated ecosystem service values for different dryland ecosystem types (chapter 3). For example, biodiversity-related services that were provided by dry forests were valued significantly higher (146.8 ± 45.8 *SD* Int$/ha/yr for biochemicals provision and 446.3 ± 10.2 *SD* Int$/ha/yr for biological regulation) than that of arid wetlands (1.0 ± 10.7 *SD* Int$/ha/yr for biochemicals provision) and semi-deserts (0.9 ± 9.6 *SD* Int$/ha/yr for biological regulation). This could have been due to the fact that dry forests typically have a rich biodiversity base and belong to the world's biodiversity hotspots (Miles et al., 2006; Myers et al., 2000).

Taken together with the finding that specific ecosystem factors are considered only very limited in monetary valuation, this suggests that broad ecosystem factors are incorporated to some extent in the valuation of water quantity-related ecosystem services, while specific ecosystem factors are largely neglected. Specific differences in ecosystem factors may, however, have significant effects on the ecosystems' capacity to deliver ecosystem services. For instance, the ecosystem service benefits provided by restored tropical dry forests are substantially higher than those provided by degraded forests (Birch et al., 2010). Not accounting for differences in the ecological status of the ecosystem may therefore hinder an accurate capturing of ecosystem service values.

Also for *water quality-related services* in the Scheldt river basin, ecosystem and spatial factors were found to be of minor importance in explaining variation in estimated monetary values (i.e. they have small effect sizes; chapter 4). For these water quality-related services, various relevant ecosystem and spatial factors were analyzed, including the distance of the beneficiaries to the nearest water body, the actual measured water quality and the local land cover. Most remarkably, the indicator for the key ecosystem factor in this analysis – the actual measured water quality – was found to only marginally affect estimated values (small effect size). Instead, methodological and beneficiary factors were found to be most important in the monetary valuation of water quality-related ecosystem services (medium to large effect sizes). This finding largely corresponds with the pattern observed for water quantity-related services.

As such, this thesis finds that ecosystem and spatial factors play only a marginal role in the monetary valuation of water-related services (Figure 6.1). This suggests that these aspects may often have not been adequately captured in monetary valuation studies. It has been earlier noted that important information may easily get lost in monetary value articulation (Vatn and Bromley, 1994). As a result, economic valuation methods may neglect the pivotal role of ecosystem and spatial factors in ecosystem services valuation. This is also demonstrated in this thesis by the finding that important characteristics of the study context – that ultimately determine the capacity and demand for ecosystem services – are only marginally taken into account in valuation. This highlights a potentially important limitation of monetary valuation of ecosystem services, especially given the simultaneous finding that valuation outcomes appear to be dominated by the selected methodological approach.

6.1.3 Methodology matters most in monetary valuation

Also remarkable is that simultaneously with the small role of ecosystem and spatial factors, the effect of methodological factors was found to be strong (Figure 6.1). For both types of water-related services, different aspects of the selected methodology were found to play a large role. In the monetary valuation of water quantity-related services, three specific methodological factors were accounted for: year of valuation, the selected extent of the study area and type of valuation method (chapter 2). The latter differentiated between market pricing, production function, cost-based, contingent valuation and benefit transfer methods. The impact of both the selected study extent (of total variation explained: between 9 – 20%) and selected valuation methods (60%) on value estimates was considerable and accounted for the largest part of the explained variation, while ecosystem and spatial factors explained a much smaller part of the total explained variation (around 30%; in addition to around 40% by beneficiary factors).

The large impact of the type of valuation method on value estimations coincides with the finding that monetary value estimates of individual services were found to be highly different when estimated with different valuation methods (chapter 3). For instance, direct market pricing estimated low values for climate regulation (5.2 ± 3.4 *SD* Int$/ha/yr), while cost-based methods estimated high values for this service (273.4 ± 6.3 *SD* Int$/ha/yr; as compared to other valuation methods). The high value by cost-based methods might approximate a more realistic value estimate: the low value by direct market pricing was probably due to the at-the-time low market price for carbon (Andrew, 2008). Also, outlier value estimates were typically observed for services that were estimated with benefit transfer, such as for fresh water provision (1,443.9 ± 3.5 *SD* Int$/ha/yr). This could have been due to the secondary nature of this method that inherently introduces additional uncertainties (Brouwer, 2000). Given these results, cost-based methods seem to be more reliable in estimating the value of regulating services than market pricing and benefit transfer methods.

Due to such differential effects of specific valuation methods on the value estimates for specific ecosystem services, also a large impact on aggregated mean values for dryland ecosystem services was observed (chapter 3). When less robust valuation methods (e.g. methods that were not originally developed for valuation of these specific services) were excluded, aggregated values for ecosystem services were significantly different. For instance, the aggregate value estimate for climate regulation increased significantly when values that were estimated with direct market pricing were excluded (from 24.9 ± 11.0 *SD* Int$/ha/yr to 273.4 ± 6.3 *SD* Int$/ha/yr). This shows that the use of less robust valuation methods for the valuation of specific services may result in biased estimations for ecosystem service values.

Similarly, in the monetary valuation of water quality-related ecosystem services, ecosystem and spatial factors were of minor significance (having small effect sizes), while methodological factors were found to have a major impact (having medium to large effect sizes; chapter 4). Components of the methodological set-up of the WTP-survey were the type of WTP question that was asked (dichotomous choice or open-ended), the amount of money that was put forward (proposed bid price) and the certainty to be willing to pay this amount. For both dichotomous choice and open-ended WTP questions, specific characteristics of the survey were found to be the most important explanatory variables, overall (having medium to large effect sizes). This contributes to previous studies on the WTP for aquatic and urban ecosystems, in which survey characteristics, such as elicitation and survey formats, were also found to systematically affect value estimations, but which did not quantify the size of these effects (Brander and Koetse, 2011; Brouwer et al., 1999; Johnston et al., 2005).

For both types of water-related ecosystem services, methodological factors were thus found to have a large impact on estimated monetary values, while simultaneously the effects of other factors were much smaller. This demonstrates the sensitivity of monetary value estimation to the selected methodological approach. As a result, estimated monetary values can be largely determined by methodological artefacts. In particular, the impact of the selected valuation method on estimated values was found to be large. This finding is new to the literature. Previous meta-analyses about monetary valuation of ecosystem services in different biomes and regions found effects of valuation methods on monetary values – varying from no effects (Ghermandi et al., 2010) and several effects (Brander et al., 2006; Woodward and Wui, 2001) to effects for all the valuation methods considered (Brander et al., 2007; Quintas-Soriano et al., 2016), but

did not quantify the size of these effects. Hence, it is impossible to compare those results with the effect sizes found in this thesis.

The selected methodology can thus have a large impact on valuation outcomes and several valuation methods were found to substantially under- or overestimate the value of specific ecosystem services. Jointly, these findings could lead to systematic bias in monetary value estimations for ecosystem services. This finding is also new to the literature. Previously, multiple studies have already argued that the valuation approach could theoretically determine the outcome (e.g. Brondízio et al., 2010; Jacobs et al., 2018; Vatn, 2009), but this has only sparsely been supported with empirical evidence (Martín-López et al., 2014; Quintas-Soriano et al., 2016). The findings of this thesis provide empirical evidence of the impact of the selected methodology on monetary valuation outcomes in the case of both water quantity- and water quality-related services.

The effects found for methodological factors are problematic in light of Aldous Huxley's aphorism: *"The end cannot justify the means, for the simple and obvious reason that the means employed determine the nature of the ends produced"* (1937). The finding that the means employed actually determine the results in this case casts doubts upon the validity of monetary valuation of water-related services.

6.1.4 Limited comprehension of ecosystem service benefits

In contrast to the first three trends, the last trend found in this thesis does not specifically concern monetary valuation, but has significant implications for it. When estimating monetary values of ecosystem services by means of stated preferences methods, such as WTP, it is important that beneficiaries of these services can adequately comprehend the benefits that they offer. Whether beneficiaries actually do so, was investigated for water quality-related services in the Scheldt river basin (chapter 5). It was found that although people can differentiate between 'good' and 'not good' water quality, they cannot perceive more subtle differences in water quality status. At the same time, it was also found that people let their perception of the water quality influence their WTP for water quality-related services, as perceived water quality significantly affected the WTP (chapter 4).

People thus have difficulties to judge water quality and this can significantly affect the WTP for water quality-related services. These findings are especially relevant for stated preference methods, because these methods assume that beneficiaries can distinguish between differences in ecological status (Johnston et al., 2017). This assumption can be problematic when perceptions of water quality are different than the actual measured water quality. This can be particularly problematic, when the water quality is perceived as better than it actually is. This could lead to an underestimation of the public benefits of water quality-related services and, thus, substantially mislead decision-making.

The finding that beneficiaries of ecosystem services have difficulty to correctly judge the water quality of water bodies in their local surroundings implies that evaluation of the water quality can be best left to experts (rather than expecting laymen to make a sound judgment). After all, subtle differences in the ecosystem's ecological status, that are difficult to observe without actually measuring water quality, do affect the services that can be delivered, as well as the quantity and quality of the services. For instance, in a river ecosystem that has clean,

oxygen-rich water, but lacks gravel beds, salmon and trout will not be able to persist because they require gravel beds as spawning grounds (Louhi et al., 2008). Such a subtle characteristic of the ecosystem may have a huge impact, for instance, on the degree to which commercial fisheries and recreational angling activities can be practiced.

In addition, if a WTP survey is used, it is important to critically consider which information will be presented about the actual water quality. In the survey analyzed in this thesis, actual water quality status was presented on a regional scale, which may have been difficult to grasp for respondents. More localized information about the actual water quality status, for example only about several of the nearest water bodies, may help beneficiaries to better comprehend the local water quality. This way, respondents may also associate the information provided with their own observations of the water quality in their local surroundings. Of course, it is also important to clearly present easy-to-understand information, for instance presented on a local map or using the local names of the water bodies, as preference-based WTP surveys can only include a limited degree of ecological detail (Johnston et al., 2017).

Furthermore, it is vital that beneficiaries of ecosystem services can adequately comprehend the relation between the ecosystem's ecological status and the ecosystem services that can be produced in order to be able to give a sound estimate of their WTP. Specifically, beneficiaries need to understand what differences in ecological status mean for the services that can be delivered (and in what quantity and quality). Especially in stated preferences studies, this requires a clear explanation of what differences in ecological status mean for service delivery (Johnston et al., 2017; Schultz et al., 2012). For instance, focusing on ecosystem conditions that are key for changes in service provision may help to simplify these otherwise complex ecological relations. In the abovementioned example about trout and salmon, the key indicator of the ecosystem to communicate would be the presence of gravel beds for commercial and recreational fishing activities. In addition to these services, the presence of gravel beds may be beneficial for other services, such as flood attenuation and sedimentation. Presenting such interrelated ecosystem conditions and service benefits may require a well thought out means of communication.

In order to comprehend the relation between the ecological status and the ecosystem services that can be produced, it is also needed that beneficiaries are aware about the actual ecosystem service benefits that they use and enjoy, both actively and passively. Passive use of ecosystem service benefits (i.e. indirect, optional or non-use values), such as the use of naturally purified drinking water or the enjoyment of biking alongside a healthy river, may go easily unnoticed. Services that are actively used (i.e. direct use values), such as the production of food or raw materials, will be more easily recognized as benefits from ecosystems. Besides the type of service, the spatial scale of service delivery and socio-economic conditions of the beneficiaries may affect people's awareness about ecosystem service benefits (Brauman et al., 2007). Evidence for the latter was also found in this thesis, as specific socio-economic characteristics did affect the awareness about the importance of water quality improvements (in chapter 5; although this attached importance did not affect the WTP; chapter 4).

Together, the findings show that a sound understanding of the ecosystem's ecological status and its relation with the service benefits that are actually enjoyed are essential to arrive at a more accurate estimation of monetary values for ecosystem services and particularly to increase the validity of stated preference valuation.

6.2 IMPLICATIONS

The four trends found in this thesis have several important implications for society and policymaking, the practice of environmental management and for science.

6.2.1 Implications for society and policy

The main trends observed in this thesis cast doubts upon the validity of monetary valuation of ecosystem services. This has several implications for society. First, as the ecosystem services approach helps to make the benefits that people enjoy from ecosystems more tangible for the general public, it could potentially contribute to stimulating public awareness about the contribution of ecosystems to human well-being. It could raise awareness about the dependency of society on ecosystems for many different types of goods and services by making the benefits that previously may have gone unnoticed or been taken for granted more easily observable. In particular, monetary valuation of ecosystem services can contribute to create awareness (e.g. Costanza et al., 1997). Yet, this thesis shows that monetary valuation studies often have had difficulty to adequately capture relevant characteristics of the study context (i.e. ecosystem, beneficiary and spatial factors), while at the same time variation in monetary value estimates is best explained by the selected methodological approach. This implies that monetary value estimates for ecosystem services may not yet give a comprehensive reflection of the dependency of society on ecosystems.

Second, the estimation of monetary values for ecosystem services has been advocated as a means to more explicitly account for environmental effects in decision-making. This policy relevance has been a major driver of environmental sciences (Boersema and Reijnders, 2009; Gómez-Baggethun et al., 2010). Especially, economic decision-making processes that use monetary values as a leverage, such as cost-benefit analyses, can take advantage of the opportunity to incorporate environmental effects by means of monetary valuation of ecosystem services. Environmental effects of plans, projects and programmes can be added to cost-benefit analyses by estimating the monetary values of changes in produced ecosystem services. However, this thesis finds that monetary valuation captures the study context and in particular the ecological status of the ecosystem only to a limited extent. Instead the value found is largely determined by the selected methodology. Hence, monetary valuation of ecosystem services may misinform decisionmakers and lead to misplaced policymaking.

6.2.2 Implications for environmental management

Besides implications for society, the findings in this thesis also have implications for the practice of environmental management. The ecosystem services approach could potentially assist in capturing the different ecosystem services that are offered by specific landscapes, giving managers a tool to explicitly express the different services and benefits that are delivered by an area to a specified group of users (Tallis et al., 2009). Monetary valuation of ecosystem services has already been used as a successful tool to calculate the cost-effectiveness of water management measures (e.g. Boerema et al., 2014) and the benefits of land or river restoration (e.g. Birch et al., 2010; Vermaat et al., 2016).

Yet, while monetary valuation of ecosystem services thus could be a promising tool to support environmental management, this thesis suggests that estimated monetary values for

ecosystem services often do not yet incorporate characteristics of the ecological status of the ecosystem well, at least in the case of water-related services. As such, the ecosystem services approach can yet not provide meaningful information for environmental management. As monetary value estimates only reflect the ecological status of ecosystems to a limited extent, they may also fail to capture whether services are provided by degraded or healthy ecosystems. The use of such biased monetary values could therefore compromise sustainable management.

6.2.3 Scientific implications

Finally, the findings in this thesis also have implications for future research. Since the practice of monetary valuation of ecosystem services has started, many studies have looked into how specific types of ecosystem services can be valued in monetary terms and what types of valuation methods can be used to this end (e.g. Bateman et al., 2011; Farber et al., 2006). As the number of studies with estimations of ecosystem service values has been increasing (Liu et al., 2010), researchers are starting to become more aware about potential problems in capturing the value of ecosystem services in monetary terms. In the course of time, multiple shortcomings have been revealed (e.g. Schröter et al., 2014b). This thesis adds, amongst others, that WTP as a valuation method suffers not only from low response rates, but also from people being uninformed about the actual ecological status of the local ecosystem, implying that a more critical stance on WTP as a method to value ecosystem services is deserved among researchers.

Furthermore, this thesis also has implications for the recent initiatives to better capture the value of ecosystem services. These initiatives include, amongst others, 'non-monetary valuation' (Kelemen et al., 2016) and 'integrated valuation' (Jacobs et al., 2016), which have been adopted by IPBES into a 'pluralistic valuation' framework (Pascual et al., 2017). Although other aspects of the IPBES approach have been criticized (e.g. Braat, 2018), this valuation framework is generally seen as an improved means to highlight the societal importance of ecosystems in environmental decision-making (Kenter, 2018). Yet, although these recent efforts by IPBES are focusing on improving the valuation of ecosystem services, so far they have mainly focused on how to better capture the social context (Pascual et al., 2017). The findings in this thesis, showing that that the ecological status of the ecosystem is generally neglected in monetary valuation, imply that it is also important to investigate how ecological status can be (better) accounted for in ecosystem services valuation.

Finally, the thesis finds that next to ecological status also spatial and beneficiary factors are only to a small extent reflected in monetary valuation, while methodological factors mainly define the outcome. These patterns reveal that estimated monetary values do not yet capture the benefits of ecosystem services comprehensively, implying that future research needs to concentrate on how to (better) incorporate the ecological status of the ecosystem and other relevant characteristics of the study context. Ways on how to achieve this are exemplified below.

6.3 WAYS FORWARD

Based on the main trends found in this thesis, the first priority for future research is to investigate how the ecological status of the ecosystem and other relevant characteristics of the study context can be (better) integrated in the valuation of ecosystem services. Several ways to

increase the validity of monetary valuation can be thought of. First, it would be useful to investigate whether the trends and patterns found in this thesis also hold for other types of ecosystems and services. In this thesis, it was found that the ecological status of the ecosystem is neglected in the monetary valuation of water-related services, while at the same time the selected methodology is dominant. Patterns for methodology seem to be different in wetland ecosystems: the selected study extent is significant in valuation, but specific valuation methods are only of significance to varying extents (Brander et al., 2006; Ghermandi et al., 2010; Woodward and Wui, 2001). Still, for many other types of ecosystems and services, it is not yet known what the role of methodology and study context is.

When similar trends and patterns are found for other ecosystems and services, two approaches can be taken to investigate how the study context, and specifically the ecological status of the ecosystem, can be better captured in (monetary) valuation. The first approach focuses on ways to improve the practice of monetary valuation, while the second approach looks at other, complementary valuation approaches.

For *monetary valuation*, it is essential to evaluate the current set of economic valuation methods in terms of their ability to take characteristics of the study context – and in particular the ecological status of the ecosystem – into account. If it is found that these methods are able to incorporate study context characteristics, it needs to be assessed how they can be (better) accounted for in valuation. The results in this thesis suggests that the answer to the question which valuation methods works best, may depend on the specific ecosystem service valued. For climate regulation, for instance, cost-based methods seem to be more reliable than market pricing. More research into which methods work best for which ecosystem services could help to pick up more general patterns, which could help to improve the reliability of valuation studies.

A way to improve our understanding of the usefulness of various valuation methods for specific services, could be to investigate the extent to which methods capture the ecological status of ecosystems. This could, for instance, be done by means of comparing case studies that estimate the monetary value of ecosystem services that are delivered by ecosystems of differing ecological status, such as restored versus unrestored ecosystems (e.g. Acuña et al., 2013).

In addition, the findings in this thesis imply that it would be wise to include a sensitivity analysis of the methodological approach when monetary valuation is used in order to account for the impact of methodological choices. Apart from giving an indication of the sensitivity of the valuation outcome to the selected methodology, this would also make the researchers and practitioners that actually carry out the valuation studies in practice more aware about the (large) impact of the made methodological choices when setting up a valuation study.

In order to carry out a sensitivity analysis, the size of the impact of different relevant factors of the study context and selected methodology in the valuation study can be analyzed using the effect size as a measure (similarly as done in this thesis in chapter 2 and 4). Another, even better approach would be to use several different valuation methods to estimate the monetary values of ecosystem services in order to arrive at an estimated value range, although this may be time- and money-consuming. In addition to estimating the sensitivity to the use of specific valuation methods, this would also give a measure of the reliability of the value estimates.

Furthermore, as an alternative to monetary valuation, it should be explored whether *other complementary, non-monetary valuation approaches* – which are currently getting increasing

attention (e.g. Jacobs et al., 2016; Kelemen et al., 2016) – can better capture the neglected aspects of the study context in valuation. Given that the aspect neglected by monetary valuation mainly concern ecosystem and spatial factors, biophysical valuation which estimates the contribution of ecological functions and processes to the provision of services may offer an opportunity to better capture these features (de Groot et al., 2010a).

As biophysical values will have their own value metrics, different from monetary value terms, a further challenge will be to integrate the various valuation approaches into one measure (Jacobs et al., 2018). One way could be to implicitly weigh biophysical, socio-cultural and monetary values by, for instance, carrying out multi-criteria decision analysis (Pascual et al., 2017; Saarikoski et al., 2016). Alternatively, a biophysical assessment of ecosystem services could be undertaken first, which is only translated into relevant value dimensions of ecosystem service benefits in the final phase (see Mononen et al., 2016). Both these methodologies may benefit from taking a spatial-explicit approach (spatial valuation), which offers the opportunity to account for spatial variation in study context characteristics (Balmford et al., 2011), as has been shown in chapter 4 and several previous studies (e.g. Birch et al., 2010; Newton et al., 2012).

6.4 Conclusion

This thesis investigated whether characteristics of the study context are accounted for in the monetary valuation of water-related ecosystem services. Specific focus was on the role of the ecological status of the ecosystem in monetary valuation. The analysis of monetary value estimates for both water quantity- and quality-related services shows that the selected methodological approach explains most of the variation in monetary value estimates. Simultaneously, the ecological status of the ecosystem is of minor importance in monetary valuation. This casts doubts upon the validity of the methods that value ecosystem services in monetary terms. In order for the ecosystems services approach to be useful for environmental policy and decision-making, an improved accounting of the ecosystem's ecological status is needed, either with monetary valuation or the use of other complementary valuation approaches.