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Climate Change and Water Resources – An International Perspective

by

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Abstract

Climate change and its consequences are the focus of many environmental policies in the European Union but also in other countries. Whereas in the US marketable instruments like permit trading have already been implemented since the 1980s, the EU first implemented permit trading for CO_2 emissions in 2005. Climate change also influences the availability of water resources; water levels of rivers in the EU are assumed to decrease in the next decades. Decreasing water levels, in turn, heavily influence the quality of these water resources. In some countries the instrument of permit trading is also applied to the regulation of water resources (quantity and quality). This paper gives an overview of existing systems in order to show how such trading systems can create incentives for the efficient use of resources by means of pricing.

Keywords: river basin management, water trading, water quality trading

JEL classification: Q 25, Q 53

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1 Introduction

Climate Change and Its Impacts

When talking about climate change, many people primarily think about the greenhouse effect supposed to be caused by the emission of greenhouse gases. The European and the global environmental policy also appear to be focused on the reduction of greenhouse gas emissions to thwart the man-made climate change process. In 2005 the Kyoto-Protocol came into force. By this protocol reduction requirements for greenhouse gas emissions were fixed for all contracting parties on a global basis.

It soon becomes apparent that climate change would influence economic life in many ways. This paper focuses on the following aspect: current studies show that an increase of the global temperature would lead to lower water levels in many European rivers and lakes.[3] Countries in which water scarcity problems already exist, such as Spain or Portugal would, in particular, be affected. These countries suffer from long and draw summer seasons which lead to strong water scarcities in some regions of these countries.[4] Conflicts of water allocation between regions arise. In some countries water is defined as a ‘public good’ that cannot be traded privately. At the same time, the fixed water charges paid by users cover only parts of the water use. Thus, the marginal costs of additional use of water are (almost) zero. As long as use of water has no adequate price, overuse or inefficient distribution of water resources cannot be avoided. Spain is a disquieting case in point (IEE, 2001). This problem would become even more relevant if the conditions of water availability will actually got worse due to climate change effects. Incentives for the implementation of water saving measures and efficient irrigation processes must be consistent.

As a next step, one states that water quality, in turn, depends critically on water levels, i.e. water quantity. The same amount of pollution load causes quite different concentration levels, i.e. water quality levels, depending on the water quantity. Water quality levels of river basins have been increasing in the last years in most European

[3] See for example BMBF (2005).
[4] Of course, also aspects other than climate change, such as growing agricultural and industrial activities, and demographic changes, are responsible for the relative scarcity of water since they imply increasing needs for water.

countries. Water pollution problems are nevertheless of high relevance and would become even more relevant if climate change took place. In 2000, the European Water Framework Directive (WFD) came into force. This Directive requires a 'good water status' of all water bodies in the European Union,[5] which demands for well coordinated and effective measures in all countries of the EU.[6]

Environmental Policy Instruments

Different types of instruments have been implemented throughout the world in order to reach a predetermined environmental objective. In the US, permit trading systems have been implemented in several areas since the 1980s. Well known are emission trading systems for air pollution control.[7] Permit trading systems implemented in order to regulate water quality or water quantity problems are, in general, less recognized.

In Europe, primarily charges and environmental taxes have been introduced to regulate environmental problems in the past. However, in 2005, about 25 years later than the US, the EU introduced a permit trading scheme for CO_2 emission reductions: the European Emission Trading Scheme which draws on the regulations of the Kyoto-Protocol. The EU, thus, for the first time also uses this marketable instrument to air pollution control.

In some countries, such as Chile, Australia or the US, permit trading regulates also water resource problems. In Europe, however, the discussion about the application of this instrument to environmental mediums other than air is quite isolated as yet. An exemption is a UNDP/GEF[8] study which analyses the potential for a water quality trading (nutrient trading) system for the Danube River Basin.[9]

This paper gives an overview of applications of permit trading schemes for water quantity and water quality regulation. Different implementations in different countries

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[5] According to Article 2, 18 WFD, the 'good water status' for a surface water is achieved when both its ecological and its chemical status are at least 'good'. For the definitions of these terms see Article 2, 21 and 24 WFD as well as Annex V WFD.
[6] The WFD requires water management for entire river basins. As rivers rarely stop at the national frontier of a country, international coordination is relevant and is also required by the WFD.
[7] *Acid Rain Program* in order to reduce SO_2 in the US (1995), *Regional Clean Air Incentives Market* (RECLAIM) in order to reduce ozone in California (1994), *NO_X-Budget Trading* in the US (1999) in order to reduce ozone and others.
[8] United Nations Development Programme/Global Environment Facility.
[9] For more information on the project, see http://www.icpdr.org/undp-drp/ (April 2006).

show how a price for water resources can be created in order to solve water conflicts (in both quantities and quality).

2 Experiences in Water Trading and Water Quality Trading

2.1 Water Trading

Permit trading systems for the regulation of water quantity problems (water trading) seek to bring the scarce water resources in the most efficient use. Permits contain the right to use parts of the existing water resources. If a user is able to reduce the use of water, e.g. through the implementation of more efficient irrigation systems, he can sell the surplus of permits on the market. An increase in the use of water has to be covered by a purchase of additional permits. This instrument thus creates a price for the use of water resources. By this, efficient use of water should be guaranteed and overuse avoided.

This paper will appraise central elements of the water trading system in Chile and Australia (New South Wales). These systems are selected due to the valuable databases available.

Chilean Water Market

Chile’s regions are very heterogeneous concerning water availability: whereas availability of water resources in the south is sufficient, the north is characterised by water scarcity. In addition, water supply and demand are very volatile over time. The irrigation sector uses nearly 85 percent of the consumption of water resources (Etschmann, 2002, p. 113). The system of tradeable water permits was implemented through the *National Water Code* in 1981.[10] Until 1981 water resources had been governed by the state. Water resources still belong to the state; however, private actors can obtain the right to use these resources even if they do not obtain property rights in the original meaning (Malz and Scheele, 2005, pp.12). The allocation of water permits is separated from land; permits can be traded freely, except for a few restrictions. The state granted property rights without charge to existing water users, such as farmers, industrial firms or water and power utilities; new and/or unallocated water rights are allocated by auction (Holden and Thobani, 1996, p. 7).

[10] See Bauer (2004, p.3).

The Chilean water trading scheme is characterised by different types of permits: *consumptive* or *non-consumptive permits,* on the one hand, and *temporary* or *permanent permits,* on the other hand. Licensees of consumptive permits are not obliged to reintroduce the water into the body of water; non-consumptive permits grant the use of water to the owner, e.g. power stations, as long as it is returned to the body of water at a specific location in an adequate quality (Holden and Thobani, 1996, pp .7). Whether water is returned to the medium or not, influences the water availability for other actors. Permits are mostly defined in terms of volumes per time; nevertheless, they are in practice often distributed in percentages of the available water quantity (Grobosch, 2003, p. 209). Changes in the total amount of available water are thus taken into account: the absolute value of permits changes over time as it depends on the total amount of water available.

An official water market in form of an exchange does not exist (Grobosch, 2003, p. 210). Permit licensees are trading directly with each other. The water authority only controls trading activities.[11]

The local distribution of trading activities has been heterogeneous (Holden and Thobani, 1996, p. 8; Grobosch 2003, p. 211). In regions with high precipitation nearly no trading activities have been observed. However, in arid regions trading activities took place; reflecting water scarcity and generating welfare benefits by leading the water to its most efficient use (Malz and Scheele, 2005, p. 14).

The water market in Chile is often called a success (separation of land and water permits, flexible allocation, welfare benefits…) and has become the world's leading example of a water trading scheme. However, a more detailed analysis of the system reveals some inefficiencies. Bauer (2005), for example, shows that market incentives which were supposed to promote a more efficient use of water, in the agricultural sector, in particular, did not work as expected; irrigation efficiency is still low. In consequence, the government continued to subsidise irrigation works. This contradicts the idea of a market mechanism. Besides these institutional aspects, Bauer (2005) criticises that the definition of water rights is too vague and sometimes

[11] Permits are rarely sold permanently but left to somebody for a predetermined period of time; it is a kind of leasing.

incomplete.[12] Only well defined water rights would create the incentive to participate in trading. The instrumental design needs to be determined more precisely and in more details.[13] It is not obvious to which extent the system integrates the correlation between water quantity and water quality issues. Since water quality is directly influenced by the level of water quantity, this aspect is of great importance.

Water Trade in the Southern Murray-Darling Basin, New South Wales, Australia
Australia is to a large extent characterised by high aridity. Precipitation varies over time; available water resources are decreasing from the north to the south of the country. At the same time, water demand in Australia is amongst the highest in the world (Malz and Scheele, 2005, p. 16). Overuse of water has been a problem for a long time in Australia. No uniform legal framework in the States and Territories existed; the water market was characterised by different local regulations (Malz and Scheele, 2005, p. 15). In 1994, the *Council of Australian Governments (CoAG)* developed a catalogue of measures in order to guarantee the efficient use of water resources. In this context, the application of economic principles and the expansion of the water trade is required (Malz and Scheele, 2005, p. 15). In 2004, the CoAG agreed to a *National Water Initiative* that also seeks to expand water trade in order to guarantee the effective and efficient water use (Peterson et al., 2004, p. 1).

Tradeable permits have been introduced, separated from land, which issue the right to use a predetermined part of the resource. Governmental agencies are responsible for allocation, modification and transfer of these permits. The specific design of permits varies significantly between States which, of course, makes trading between States difficult. Within the last years, legal regulations have been modified such that a certain level of uniformity allows for transregional trading activities. Nevertheless, in parts crucial differences in the design of entitlements exist even today (Malz and Scheele, 2005, p. 17).

The water trading scheme in the Southern Murray-Darling Basin is an example for the implementation of a trading scheme within different regulations of single States of Australia. New South Wales is one of the States participating in the water trade in the

[12] For more details, see Bauer (2005, pp. 153).
[13] Since the 1990s the government disagrees whether to reform the Water Code and, if so, how to do it. The fate of the reforms, however, remains quite uncertain (Bauer, 2005, p. 155).

Southern Murray-Darling Basin in Australia. Permits are allocated to irrigators and define the access right to a specific quantity (in percentages) of water in each irrigation season. Changes in water quantity are thus integrated automatically.[14]

Whereas irrigators in New South Wales can partly transfer unused permits to the next season, in Victoria surplus permits cannot be carried over (Peterson et al., 2005, pp. 115). Such differences in the instrumental design, of course, cause inefficiencies and can hamper the market to come to an efficient solution.

One particularity in New South Wales is the differentiation between *high security entitlements* and *general security entitlements* (Malz and Scheele, 2005, p. 19). The former contain the right to use water resources in accordance with the permits even in very dry periods, whereas the latter are restricted in validity in periods of water scarcity.[15] Permits are thus associated with different risks which would be reflected in the prices. Only high security entitlements are tradeable; special conditions apply.[16] In Victoria and South Australia this differentiation does not apply (Peterson et al., 2004, p. 5). These differences also cause inefficiencies.

Electronic exchanges and brokers facilitate trading activities (Peterson et al. 2005, p. 116). Trade volumes vary considerably from year to year depending on seasonal conditions and allocations. Peterson et al. (2005) state that the price of permits varies a lot in space and time, which would, on a functioning market, reflect different scarcities. At the same time, Peterson et al. (2005) conclude that the development of prices also depends on different regulatory arrangements, i.e. on the institutional framework.[17] Different definitions and instrumental designs in different States of Australia hinder trading activities between States. The link between water quantity and quality issues appears weak in this trading scheme (Peterson et al., 2005).

[14] Peterson et al. (2005, p. 116) differentiate between trade in *water entitlements* and *seasonal water allocation*. Whereas trading in water entitlements (sometimes called ‘permanent trade’) signifies a final and permanent transfer of permits to another participant, trading in seasonal water allocations (‘temporary trade’) corresponds to a temporary transfer of permits, i.e. for the current irrigation season or an agreed number of seasons.

[15] Drinking water supply processes are prioritised.

[16] Another particularity of New South Wales is the existence of so called *native title rights*: beforehand allocated water use rights that depended on land endure. These are mostly rights which have been admitted to original inhabitants. These permits are, however, not tradable (Malz and Scheele, 205, p. 19).

[17] For more details, see Peterson et al. (2004, pp. 9).

2.2 Water Quality Trading

Water quality trading seeks to reach a specific water quality standard at least costs. Sources of pollution are obliged to hold a sufficient number of permits in order to introduce pollutants into the water. If sources reduce their discharge, surplus permits can be sold on the market.

In the US, in particular, different forms of quality water trading systems have been tested and implemented in several river basins since the 1980/90s.[18] Breetz et al. (2004) describe existing programmes in the US in more detail.[19] Their study shows that approximately two thirds of the programmes concern phosphorus and/or nitrogen (nutrients). Other traded pollutants are selenium, heavy metals or even the 'pollutant' temperature.[20] However, a critical analysis of some of these programmes shows that a permit trading in the original definition does not exist. Actually, permits are only rarely traded. This might create the impression that the lack of trading activities, at least in some cases, stems from the given design of the system. The example of the *Tar Pamlico Nutrient Trading Program, US* shows how important the specific design of the permit trading scheme is for the effectiveness and the efficiency of the system. This example was selected for this paper, because it is often mentioned in the literature as a success, and hence comes along with a valuable basis of information.[21]

In Australia, water quality trading schemes have also been introduced; only in the last 10 years though. For the regulation of water quality, one trading system, in particular, is often cited in the literature: the *Hunter River Salinity Trading Scheme (HRSTS)*. This example was selected for this paper because of its outstanding structure: the

[18] For more information, see Environomics (1999), Kraemer et al. (2003) or NIRAS (2004).
[19] For another presentation, see Kraemer et al. (2004) or Environomics (1999).
[20] Breetz et al. (2004, pp. 8). The integration of nonpoint sources can make sense from an economic point of view because the marginal abatement costs are assumed to be much lower for nonpoint sources than for point sources. For the example of the Tar Pamlico Nutrient Trading Program it is assumed that the marginal abatement costs for point sources are about seven times higher than those for nonpoint sources. However, due to the complicated assignment of individual responsibility, the integration of nonpoint sources should be designed very carefully in order to guarantee efficiency. Another approach would regulate nonpoint sources separately (see Keudel, 2005).
[21] See, for example, the website of the N.C. Division of Water Quality (http://h2o.enr.state.nc.us/nps/tarpam.htm, January 2006).

system integrates specific characteristics of the Hunter River as well as of the pollutants concerned in an impressive manner.[22]

Tar Pamlico Nutrient Trading Program, US

The Tar Pamlico River is situated in North Carolina (US). The agriculture along the river is responsible for a high proportion of the river pollution; but also point sources such as sewage treatment plants contribute to it (Faeth, 2000, p. 15). In 1989, the North Carolina Environmental Management Commission (EMC) declared the river ‘nutrient sensitive’ water. In order to decrease the level immission load, the Nutrient Trading Program was implemented in 1990. It covers the entire river basin. This trading programme includes point sources as well as nonpoint sources; traded pollutants are phosphorus and nitrogen (nutrients). The majority of the point sources is member of the *Tar Pamlico Basin Association*. The system treats point sources in this Association as one single unit, with the goal to achieve the given water quality standard within the Association at a higher level of cost-effectiveness. When exceeding the standard, the Association has to pay an ‘incentive fee’ for each unit of pollution exceeding the cap. This incentive fee is predetermined, payments flow into an – established in advance – agricultural fund set up by the state (*Agriculture Cost-Share Program, ACSP*) in order to finance abatement measures according to the Best Management Practice (BMP) at the nonpoint source level. In addition, the Association can purchase permits from nonpoint sources. But point sources cannot sell permits to nonpoint sources. For transactions between point sources and nonpoint sources a trading ratio applies, taking into account that the impact of emission reductions at the nonpoint source level on the water quality cannot be predicted accurately. Figure 1 gives an overview of the system.

[22] In this paper only implemented schemes are discussed. For an overview of theoretical approaches for water quality trading, see Keudel (2006).

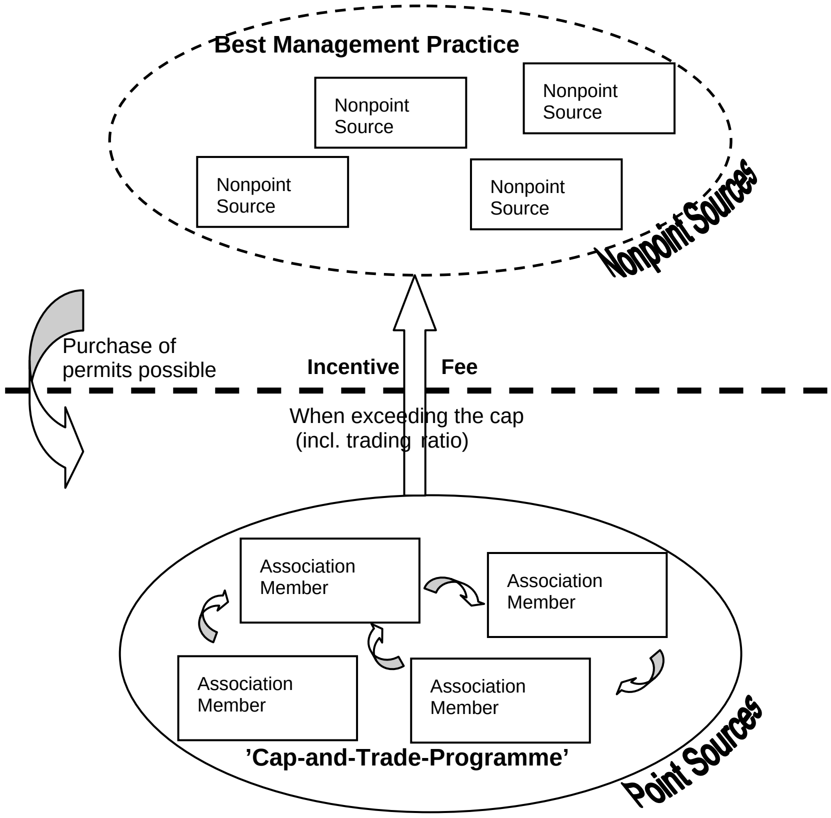

Figure 1: Tar Pamlico Nutrient Trading Program

Under the Tar Pamlico nutrient Trading Scheme, no trading activities have been observed as yet. However, point sources reduced their discharges by a higher amount than required by the cap determined by the environmental authority. Keudel and Oelmann (2005) and Keudel (2006) analyse the Tar Pamlico Nutrient Trading Program in more detail. They conclude that central elements of a permit trading are missing in the instrumental design: the cap has not been allocated individually to the point sources. There is thus no basis for trading activities. Transaction costs in the programme are assumed to be quite low; when exceeding the cap, point sources purchase additional permits by paying the incentive fee. No trading partner has to be identified; no reduction activities have to be monitored etc. However, inefficiencies caused by this instrumental design are assumed to overcompensate the low level of transaction costs. Keudel (2005) shows that other common economic criteria are not fulfilled by the design of the trading programme. The existing institutional framework does not appear to cause inefficiency. Water quality problems are regulated without integrating the existing link to water quantities.

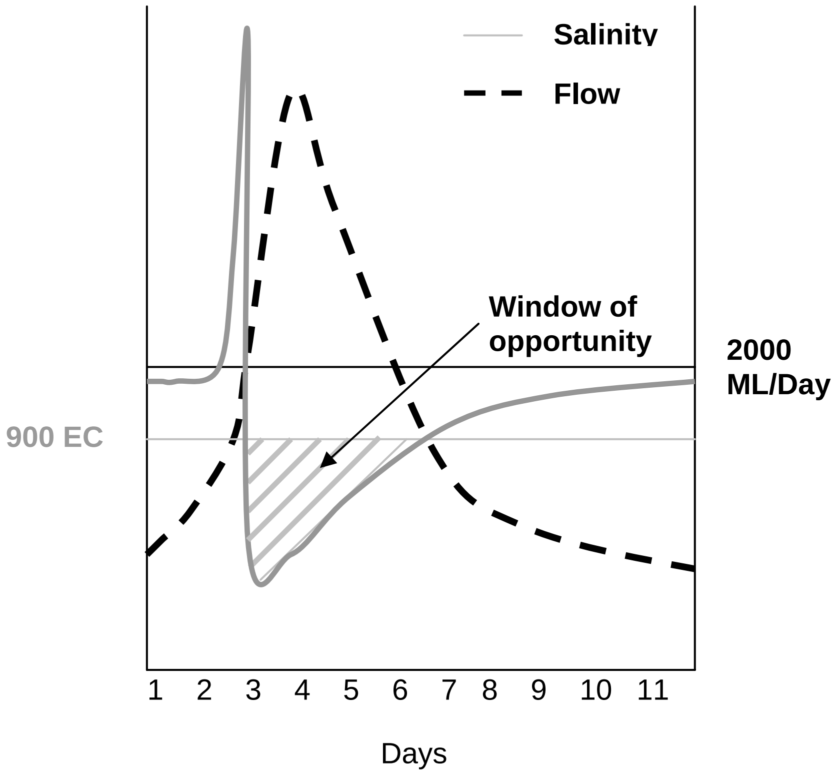

Figure 2 – Salinity and water flow, HRSTS (NSW EPA, 2003, p. 6)

Hunter River Salinity Trading Scheme, Australia

In the region of the Hunter River, the agricultural sector is of high importance. Also, it is home to more than 20 coal mines and to three power stations (NSW EPA, 2003, p. 3). The critical substance in this river is salt. Salt occurs naturally in many of the rocks and soils of the Hunter Valley and thus in the river. But by introducing saline water, sources such as coal mines and power stations contributed to an increasing salinity in the river (HITS, 2004; NSW EPA, 2003, p. 3). As a result, the water could not be used for irrigation in agriculture anymore (NSW EPA, 2003). This let the *NSW Department of Land and Water Conservation (DLWC)* and the *NSW Environment Protection Authority (NSW EPA)* introduce the HRSTS, a system with dynamic and tradeable discharge permits.[23]

River monitoring has shown that, at the beginning of a high flow period (‘event’, see broken line, Figure 2), the salinity of the water increases significantly for a short

[23] After a pilot phase the HRSTS was finally implemented in December 2002. The basic document is the *Regulation of the Environmental Operations (Hunter River Salinity Scheme) Regulations 2002* (NSW DEC, 2004).

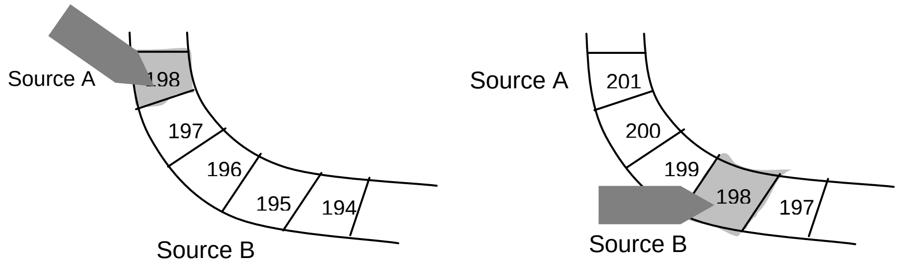

Figure 3 – Trading in blocks, HRSTS (NSW EPA 2003, p. 5)

while, followed by a strong decrease (see continuous line, Figure 2).[24] The idea behind the system is the following: licensees are allowed to introduce saline water when the impact on the water quality is – because of the high volume of fresh water – the lowest possible (HITS, 2004). Whereas discharges are not allowed in low flow periods, they are allowed (in accordance with the permits) in periods of high flow using the 'window of opportunity' (NSW EPA, 2003, p. 4).[25] The permitted amount of discharges depends on the current salinity and may change every day (dynamic discharge permits).[26]

The total amount of allowed discharges is defined for 'blocks' (see Figure 3). A block is "a body of water that flows down the Hunter River and that is predicted to pass the [...] reference point in a 24-hour period" (NSW EPA, 2002, Division 1, 9, 2).[27] These blocks represent a volume unit of water that is flowing through the river bed from the origin to the estuary. Figure 3 shows that block *198* passes source *A* within a 24-hour period; some days later the block *198*, i.e. the same volume of water, passes source *B*. The water flow as well as the salinity is measured permanently for each individual block (HITS, 2004). Based on these data, the amount of salinity which can be introduced additionally by the sources is defined (NSW EPA, 2003, p. 4; NSW EPA, 2002, Division 1, 9). In consequence, the application of this system

[24] The additional amount of water washes salt from the ground and surface into the river. The following volume of fresh water diminishes the salinity of the water (HITS, 2004).
[25] For the exact definition of the terms 'high flow' and 'low flow', see NSW EPA (2002, Part 2, Division 11-14 and Part 3, Division 1, 17).
[26] In a period of flood, saline water can be emitted without permits (Brady, 2004, p. 11; NSW EPA, 2003, p. 4)).
[27] In total there are 365 blocks per year which are numerated per day and year.

requires an intensive monitoring system.[28] Also on part of the licensees, a precise monitoring is required (NSW EPA, 2002, Part 5, Division 3).

In total 1000 permits have been allocated. Each permit allows the licensee – and this is another particularity of the system – to introduce 0,1 percent (!) of the total amount of discharges allowed for a defined block (in our example the block *198*) into this very block (HITS, 2004; NSW EPA, 2003, p. 5). Licensees can trade these permits (tradeable discharge permits) for a single block or for sequential blocks.[29]

The HRSTS shows how specific characteristics of river and pollutants can be integrated adequately into the instrumental design. High trading activities guarantee the efficiency of the system. Furthermore, the system has been implemented in consistence with the existing institutional framework. Keudel (2005) shows, that the HRSTS fulfils the economic criteria. The particularity of the HRSTS is that this water quality trading scheme introduces, by means of the block design, also water quantity aspects. The absolute value of permits, issued as a share (percentage) of a varying remaining intake capacity (depending on water level and salinity), varies over time and automatically integrates the current water quantity conditions.

3 Conclusion

This paper aims to show that permit trading is a potential instrument to solve water quantity or quality problems and gives an overview of existing trading systems. Permit trading seeks to bring water resources in the most efficient use (quantity) or to reach a determined quality level at lowest costs (quality). However, the discussion of different practical approaches in the US, Chile and Australia has shown that instrumental design and institutional framework vary a lot in different countries. At the same time, these two elements critically influence functionality, effectiveness and efficiency of a permit trading scheme: only in a well designed trading scheme that is well linked to the existing institutional framework, the price can avoid overuse of water resources. The analysis has shown that the correlation between water quantity

[28] Monitoring points select information for the whole length of the river. Every 10 minutes, data on the water flow and the salinity of the water are collected and transmitted via radio or telephone to the central data warehouse. River modelling experts use these data to calculate the total emissions allowed (NSW EPA, 2003, p. 7).

[29] Each trade has to be approved by the EPA (HITS, 2004; NSW EPA, 2002, Part 5, Division 2, 56). Permits do not expire upon use (NSW EPA, 2001, p. 37). For further information about the trading of permits see NSW EPA (2002, Part 5, Division 2).

and quality is very direct and thus relevant for the design of permit trading schemes. Nevertheless, water quantity and quality issues have rarely been integrated into trading schemes in practice.

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