Chapter 3

OECD Countries' Policy Experiences[1]

3.1. Policy overview and objectives

All OECD countries have policy strategies to address broad water management issues – water resources, quality and ecosystems – and in terms of the more specific objectives for managing water resources in agriculture they broadly share a common strategic vision to:

- Establish a long-term plan for the sustainable management of water resources in agriculture taking into account climate change impacts, including protection from flood and drought risks;
- Contribute to raising agricultural incomes and achieving broader rural development goals;
- Protect ecosystems on agricultural land or affected by farming activities;
- Balance consumptive water uses across the economy with environmental needs; and,
- Improve water resource use efficiency, management and technologies on-farm and ensure the financing to maintain and upgrade the infrastructure supplying water to farms (and other users).

Most OECD countries have established policy targets to meet the strategic vision for agricultural water management listed above, although the emphasis varies between countries reflecting differing national priorities (see the OECD questionnaire at www.oecd.org/water). The policy targets for agricultural water resource management across OECD countries reveal that:

- Quantified policy targets are established by a third of OECD countries, usually in terms of a specific planned increase in the area to be irrigated or a financial target mainly aiming to improve water use efficiency in agriculture (*e.g.* **Canada, Greece, Italy, Korea, Mexico, Portugal, Spain, Turkey**);
- Sustainable limits on the use of surface water and groundwater are a key focus of many countries policy targets, especially to ensure sufficient quantities of water to meet environmental needs (*e.g.* **Australia**);
- Frequently while there are no overarching national policy targets there are more often targets for water resource management established at the water basin or local level of management (*e.g.* **Australia, Belgium, Canada, France,** the **United States**);

- Where irrigated agriculture is important policy targets usually seek to improve water use efficiency and upgrade the existing water delivery infrastructure (*e.g.* **Greece, Italy, Mexico, Portugal, Spain, Turkey,** the **United States**); and, that
- An increasing number of countries are linking policy targets and plans across the domains of agriculture, water and climate change (*e.g.* the **United States**) (see the OECD questionnaire at www.oecd.org/water).

Policy responses by OECD countries in moving towards the sustainable management of water resources in agriculture are in most cases part of a package that encompasses a mix of: policy instruments (*e.g.* market-based, economic, regulatory and planning approaches); institutional reforms; and community engagement. The key policy domains affecting water resource management in agriculture examined in this report cover:

- Agricultural and agri-environmental policies (Chapter 3.2);
- Farm management and technology measures (Chapter 3.3);
- Water policies and agriculture (Chapter 3.4);
- Climate change and flood and drought risk management (Chapter 3.5); and,
- Knowledge and assessment of water resource management in agriculture (Chapter 3.6).

For most OECD countries their policy strategies for water resources often seek to link these different elements together in a coherent policy framework. The Integrated Water Resource Management approach is one way in which some countries have tried to better integrate the various policy dimensions of water resource management, but its adoption in practice has been difficult and more limited (Box 3.1).

3.2. Agricultural and agri-environmental policies

3.2.1. Overview

Agricultural and agri-environmental support policies across OECD countries act to provide an intricate mix of incentives and disincentives toward the sustainable management of water resources. The widespread use of crop and livestock market price support provides incentives to intensify agricultural production, while support for farm inputs, especially water, drainage and energy (for water pumping) misalign farmer incentives and can aggravate overuse and create pollution and other environmental damage to water resources. The disincentives caused by these farm support measures for improving water resource management is further compounded by support for water irrigation infrastructure costs and support to lower water supply charges for agriculture.

The shift to agricultural policy measures not linked to production (decoupled) or the unconstrained use of inputs is likely to lead to a positive outcome for water resources and the environment, although the cause and effect relations here are complex. Hence, the increasing adoption of agri-environmental measures by OECD countries has both a direct (*e.g.* wetland conservation) and indirect (*e.g.* conservation tillage helping to retain soil moisture) effect on improving water resource management and environmental outcomes.

Box 3.1. Integrated water resource management: Potential and limitation

To improve the integration of different institutions and policy measures covering water management, Integrated Water Resource Management (IWRM) came to prominence over the 1990s, as a possible solution to enhance integration and policy coherence. Advocates see IWRM as a process which promotes the co-ordination of water, land, and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of ecosystems. The World Summit on Sustainable Development in 2002 called for all countries to adopt IWRM strategies.

Although IWRM has been widely embraced by international organisations and researchers, its adoption in practice by countries and regions appears more limited. While IWRM may work for some micro-scale water management projects, there appears to be no evidence that it has been effective for large projects. Some key drawbacks to the IWRM approach appear to be that:

- It is defined in too general terms to be easily interpreted for practical implementation;
- The concept is too complex to be managed;
- There has been little consideration given to how to monitor if a system is becoming integrated;
- The concept overlooks the integration with other sectors in the economy, such as the energy sector;
- Climate change, and more recently concerns over energy security has exposed water systems to situations never envisaged by those who originally developed the IWRM concept, and requires more innovative water management regimes and institutional arrangements.

Source: Adapted from Biswas (2008); Global Water Partnership (2000); Mukhtarov (2008); Pahl-Wostl (2008).

As long as market support for commodity production remains and water and energy support to farmers persists, however, this will work against the gains from decoupled support measures. But decoupling support from production and inputs appear to provide a basis for improving water efficiency and enhancing environmental benefits in agriculture, especially where there is a cross compliance condition attached to a decoupled payment (*e.g.* authorisation of water abstractions rights as a precondition for implementing "good" agri-environmental practices).

Overall, isolating and quantifying the overall economic efficiency and environmental effectiveness of agricultural and agri-environmental support on water resources, however, is difficult, and further analysis on causation is needed. This is because farmers are usually responding to a very complex set of signals in making water management decisions, including institutional constraints (*e.g.* regulations on water allocations), or because the change in relative prices associated with reduced output-linked payments may cause farmers to switch to previously non-supported crops that are more water intensive than those that benefited from coupled support payments.

3.2.2. Trends in agricultural support[2]

OECD agricultural support indicators show a gradual lowering of the Total Support Estimate (TSE) over the period 1990-92 to 2006-08. The downward trend was evident in the Producer Support Estimate (PSE, *i.e.* support for agricultural producers) as a share of farm receipts, and the General Service Support Estimate (GSSE, *i.e.* support for the agricultural industry but not producers individually) as a share of GDP. From 1990-92 to 2006-08.

Overall support specifically related to management of water resources in agriculture (*i.e.* support for irrigation, drainage, and conservation of aquatic ecosystems related to farming activities) ***is a very small share of the OECD TSE*** to agriculture, accounting for just under 2% of the TSE (2006-08), its share of the TSE rising by 18% since 1990-92 (Table 3.1). For some countries this share is much higher such as in **Australia** (7%) and **Japan** (8%), but these two countries are marked by very different absolute levels of producer support in total farm receipts (%PSE), respectively in 2006-08, 6% and 49%.

In broad terms, the reduction in overall agricultural support has helped to reduce pressure on the use of water resources by agriculture. This pressure has been further eased due to the decrease in the share of OECD support most linked to commodity production and unconstrained use of inputs (such as water and energy), which fell from 81% in 1990-92 to 55% in 2006-08.

This is reflected in the ***trends in support for irrigation,*** which although the TSE increased from 1990-92 to 2006-08 (+26%), it has seen a reduction in water producer support (PSE -7%) but rise in support provided for off-farm water supply infrastructure for agriculture (GSSE +36%). There has also been greater emphasis on support for water efficient technologies, management systems, farmer education and advisory services, and research and decision planning systems related to water resource management.

Despite the increase in total OECD support (TSE) to cover the investment and maintenance costs for ***farmland water drainage*** facilities, such as surface ditches and drainage, and sub-surface drainage pipes, this has been confined to only a very few countries (**Korea, Poland, United Kingdom**). The majority of OECD countries have either ceased making these payments or they have been gradually reduced and strictly regulated in conjunction with wetland conservation measures (Chapter 3.2.5).

Support for energy inputs in agriculture has been stable/declining in many cases, and while this support is usually provided to lower costs of electricity or diesel fuel for farm machinery and buildings, it also reduces costs for pumping irrigation water. In **Mexico** and **Turkey**, for example, support for electricity to pump irrigation is undermining efforts to achieve sustainable agriculture water resource use, especially groundwater (OECD, 2008a).

Support provided for feedstocks to produce biofuels and bioenergy has been increasing in recent years (OECD, 2008d). As the support to agricultural feedstocks to produce biofuels and bioenergy is relatively new and also covers a diversity of raw materials (*e.g.* from maize to short rotation coppice), however the overall impacts on water resources are difficult to determine at this stage, as discussed in Box 2.5.

Growing budgetary payments for agri-environmental measures linked with greater regulation of farming practices to protect the environment, has also had a positive impact on water resource management, either directly (*e.g.* payments for aquatic ecosystem services such as wetland conservation, Table 3.1) or indirectly (*e.g.* support for riparian buffer strips mainly for pollution control, but which also serve to provide flood control benefits by slowing water flows across farmland).

There has been little direct support provided for flood and drought adaptation and mitigation measures in agriculture, although indirect support is more important (*e.g.* construction of on-farm water storage facilities to combat droughts) (Chapter 3.6 and the OECD questionnaire at www.oecd.org/water). This contrasts with much higher levels of farm support in the form of flood and drought disaster relief payments to compensate for the damage to farm production and infrastructure by these events.

Overall levels, trends and emphasis of direct support for water resource management in agriculture show considerable variation across OECD countries (Table 3.1). Some countries, for example, provide have little or no support for water resource management (*e.g.* **Canada, Iceland, Norway, Switzerland** and many **EU** countries), while others have show an increasing trend in total support since 1990-92 (*e.g.* **Australia, EU27, Japan, Korea, Poland, Portugal, Spain, United Kingdom**). For other countries the level of water resource support has declined (*e.g.* **France, Mexico, New Zealand** and **Turkey**). But these varying trends in support also need to be viewed in the context of the absolute share of producer support in total farm receipts (%PSE), which varies greatly between countries (Table 3.1).

3.2.3. The effects of agricultural and agri-environmental policies on water resources

Isolating and quantifying the overall economic efficiency and environmental effectiveness of agricultural and agri-environmental support on water resources is difficult, but some research has provided insights into these relationships. Preliminary studies of the **EU** Common Agricultural Policy reforms, for example, suggest that the shift to decoupled payments has led to a reduction of irrigation (especially maize) in areas where water stress is an issue (Box 3.2).

3.2.4. Impact of agricultural support on aquatic ecosystems

All OECD countries use a combination of support payments to farmers and regulatory instruments for the conservation and restoration of on-farm aquatic ecosystems (*e.g.* wetlands, ponds) (see the OECD questionnaire at www.oecd.org/water). This support is also provided in a few countries through property/land tax exemptions for landowners protecting aquatic ecosystems (*e.g.* **Canada, France**). In some cases support is provided to farmers to protect waterscapes, and associated cultural and recreational values (*e.g.* bathing, fishing), for example, in ***Austria, Canada, France, Ireland, Japan, Korea, Portugal, Spain, Switzerland*** *and the* ***United States***.

Support payments for aquatic ecosystem conservation are usually made subject to certain regulations, such as placing limits on drainage where it affects wetland conservation (see the OECD questionnaire at www.oecd.org/water). For most countries conservation of aquatic ecosystems are linked to obligations under International Environmental Agreements, for example, the Ramsar Convention on Wetlands. Only a few countries use a ***farm pollution tax*** to protect aquatic ecosystems (*e.g.* **Czech Republic, Netherlands, Poland**).

Table 3.1. Summary of OECD countries budgetary expenditure on irrigation, drainage and aquatic ecosystem services

million USD

	Irrigation			Drainage			Aquatic ecosystems		
	1990-92 average	2006-08 average	% change	1990-92 average	2006-08 average	% change	1990-92 average	2006-08 average	% change
OECD[1,4]									
PSE	1 157	1 077	-7	175	272	56	16	315	1 849
GSSE	3 765	5 121	36	64	229	259	1	25	3 361
TSE	4 923	6 197	26	238	501	110	17	340	1 913
% of water TSE in total TSI	1.4	1.7	18	0.1	0.1	97	0.0	0.1	1 791
Total % PSE	33	23	-30						
Australia									
PSE	0	83	n.c.	0	0	n.c.	0	0	n.c.
GSSE	0	116	n.c.	0	3	n.c.	0	23	n.c.
TSE	0	199	n.c.	0	3	n.c.	0	23	n.c.
% of water TSE in total TSI	0	6.8	n.c.	0	0.1	n.c.	0	0.8	n.c.
Total % PSE	7	6	-12						
Canada									
PSE	0	0	n.c.	0	0	n.c.	0	0	n.c.
GSSE	0	14	n.c.	0	0	n.c.	0	0	n.c.
TSE	0	14	n.c.	0	0	n.c.	0	0	n.c.
% of water TSE in total TSI	0	0.2	n.c.	0	0	n.c.	0	0	n.c.
Total % PSE	32	18	-44						
Japan[2]									
PSE	151	170	12	0	0	n.c.	0	0	n.c.
GSSE	2 970	3 663	23	0	0	n.c.	0	0	n.c.
TSE	3 121	3 833	23	0	0	n.c.	0	0	n.c.
% of water TSE in total TSI	5.3	7.9	48	0	0	n.c.	0	0	n.c.
Total % PSE	53	49	-8						
Korea									
PSE	52	76	45	0	0	n.c.	0	0	n.c.
GSSE	312	874	180	62	215	248	0	0	n.c.
TSE	365	950	161	62	215	248	0	0	n.c.
% of water TSE in total TSI	1.6	3.5	116	0.3	0.8	188	0	0	n.c.
Total % PSE	74	61	-17						
Mexico[5]									
PSE	361	177	-51	0	0	n.c.	0	0	n.c.
GSSE	242	160	-34	0	0	n.c.	0	0	n.c.
TSE	602	338	-44	0	0	n.c.	0	0	n.c.
% of water TSE in total TSI	7.0	4.5	-35	0	0	n.c.	0	0	n.c.
Total % PSE	24	13	-43						
New Zealand									
PSE	0	0	n.c.	0	0	n.c.	0	0	n.c.
GSSE	6	0	-100	0	0	n.c.	0	0	n.c.
TSE	6	0	-100	0	0	n.c.	0	0	n.c.
% of water TSE in total TSI	3.8	0	-100	0	0	n.c.	0	0	n.c.
Total % PSE	1.6	0.9	-41						
Switzerland[5]									
PSE	1	2	160	2	1	-47	1	1	80
GSSE	1	2	160	2	1	-47	1	1	80
TSE	1	4	160	4	2	-47	1	3	80
% of water TSE in total TSI	0.0	0.1	227	0.1	0.0	-33	0.0	0.0	126
Total % PSE	71	60	-15						
Turkey									
PSE	32	22	-31	43	0	-100	0	0	n.c.
GSSE	18	3	-84	0	0	n.c.	0	0	n.c.
TSE	50	25	-50	43	0	-100	0	0	n.c.
% of water TSE in total TSI	0.6	0.2	-69	0.5	0.0	-100	0	0	n.c.
Total % PSE	26	21	-17						
United States[4]									
PSE	538	331	-38	0	0	n.c.	15	307	1 952
GSSE	0	0	n.c.	0	0	n.c.	0	0	n.c.
TSE	538	331	-38	0	0	n.c.	15	307	1 952
% of water TSE in total TSI	0.8	0.3	-56	0	0	n.c.	0.0	0.3	1 379
Total % PSE	17	10	-43						

Table 3.1 (continued)

million USD

	Irrigation			Drainage			Aquatic ecosystems		
	1990-92 average	2006-08 average	% change	1990-92 average	2006-08 average	% change	1990-92 average	2006-08 average	% change
European Union 27[3,4,6]									
PSE	22	215	856	129	272	111	1	8	1 325
GSSE	217	288	32	0	10	n.c.	0	0	n.c.
TSE	240	503	110	129	282	119	1	8	1 325
% of water TSE in total TSI	0.2	0.4	95	0.1	0.2	104	0.0	0.0	1 229
Total % PSE	35	27	-23						
France									
PSE	0	0	n.c.	0	0	n.c.	0.5	6.1	1 051
GSSE	216	31	-86	0	0	n.c.	0.0	0.0	n.c.
TSE	216	31	-86	0	0	n.c.	0.5	6.1	1 051
Italy									
PSE	14	164	1 102	0	0	n.c.	0	0	n.c.
GSSE	0	0	n.c.	0	0	n.c.	0	0	n.c.
TSE	14	164	1 102	0	0	n.c.	0	0	n.c.
Poland									
PSE	0	0	n.c.	37	123	228	0	0	n.c.
GSSE	1	1	-27	0	0	n.c.	0	0	n.c.
TSE	1	1	-27	37	123	228	0	0	n.c.
Portugal[5]									
PSE	5	39	722	1	0	-100	0	0	n.c.
GSSE	0	0	n.c.	0	0	n.c.	0	0	n.c.
TSE	5	39	729	1	0	-100	0	0	n.c.
Spain									
PSE	4	10	132	0	0	n.c.	0	0	n.c.
GSSE	0	252	n.c.	0	0	n.c.	0	0	n.c.
TSE	4	262	6 263	0	0	n.c.	0	0	n.c.
United Kingdom									
PSE	0	0	n.c.	91	142	56	0	0	n.c.
GSSE	0	0	n.c.	0	0	n.c.	0	0	n.c.
TSE	0	0	n.c.	91	142	56	0	0	n.c.

n.c.: not calculated

PSE : Producer Support Estimate; GSSE : General Services Support Estimate; TSE : Total Support Estimate.

1. Iceland and Norway are not included in the table because there are no entries in the OECD PSE database for irrigation, drainage or aquatic ecosystem services. Data on these items are aggregated under other headings in the database.
2. For Japan, drainage expenditure is included in irrigation, and sub-national data are included in 2007 and 2008.
3. Belgium, (Bulgaria), (Cyprus), Denmark, (Estonia), Greece, Ireland, (Lithuania), Luxembourg, (Malta), Netherlands, (Romania) are not included in the EU27 total because there are no entries in the OECD PSE database for irrigation, drainage or aquatic ecosystem services. Data on these items are aggregated under other headings in the database.
4. % share of water TSE in total TSE is as follows:
   OECD, aquatic ecosystems, 1990-92 average=0.005%
   Switzerland, irrigation, 1990-92 av.=0.02%; drainage, 2006-08 av.=0.04%,
   Switzerland, aquatic ecosystems, 1990-92 av.=0.02%; 2006-08 av.=0.05%
   United States, aquatic ecosystems, 1990-92 average=0.02%
   EU27, aquatic ecosystems, 1990-92 av.=0.0005%; 2006-08 av.=0.007%.
5. 2006-08 average refers to 2005-07.
6. National expenditure, excluding EU co-financing.

Source: OECD PSE and CSE database: see www.oecd.org/tad/support/psecse.

Box 3.2. The EU's Common Agricultural Policy reforms and water resources

EU agricultural policy "Agenda 2000" aimed at supporting a multifunctional, sustainable and competitive agriculture. It was based on the establishment of production-related direct aid payments and gave a prominent role to agri-environmental instruments to support farmers' income. In June 2003, the EU decided to replace from 2006 onward most of the direct aid with a single farm payment scheme that is not linked to production. Beneficiaries will be obliged to accomplish certain environmental and food safety requirements, and which are almost identical for irrigation and rain-fed agriculture. This means that farmers, in most EU member states are entitled to support based on the direct payments received during a reference period (years 2000, 2001 and 2002), irrespective of their cropping patterns and farm-size.

Other EU farm policy reforms affected the sugar, cotton, olive and wine sectors, making the support mechanisms less, but not entirely decoupled from production. In the case of Spain, for example, these farm policy reforms have had marked impacts on irrigated agriculture, especially in the regions where fruit and vegetables were less important in terms of value and acreage. While in the Mediterranean provinces of Spain, fruit and vegetables consume most water available for irrigation, in the mainland provinces cereals, protein and forage crops, sugar beet, potatoes and a few fruit crops have been the primary irrigated crops.

Examples of crops, across the European Union, with high water requirements that were supported by the Common Agricultural Policy (CAP) programmes were numerous. Maize is considered a water demanding crop in temperate countries, and EU growers were until 2003 entitled to a direct subsidy of EUR 54/tonne. Since the CAP direct subsidies were defined to deliver equivalent levels of income support to all cereal, oilseeds and protein crops, they favoured crops such as maize, rice, cotton or tobacco, that demand much more water than oilseed crops such as sunflower or colza (rapeseed). With decoupling, this inconsistency was eliminated, and farmers' use of water will not be driven by subsidy differences across crops. Garrido and Varela-Ortega (2008), for example, have reported the gradual but steady changes of irrigated land allocation that have occurred in Spain since the 2003 CAP reform. The major and most significant changes were that more irrigated land resources have been allocated to vineyards, olive trees and citrus (especially in Andalusia), and less irrigated lands allocated to water-consuming crops such as maize and other reformed sectors, including sugar beet, cotton and tobacco.

Many authors have established a connection between farm support and irrigation water demand in Spain (Arriaza *et al.,* 2003; Gomez-Limón *et al.,* 2002; Iglesias *et al.,* 2004; Sumpsi *et al.,* 1998). Their results indicate that the lowering of farm support has a larger impact on farmers' welfare than the rise of water prices. When EU farm subsidies become completely decoupled from production in 2012, the economics of irrigation will be more guided by the relative productivity of crops and water accessibility than by relative agricultural support granted to the crops. Moreover, Mejias *et al.* (2004) show that the EU policy based on full decoupling will likely reduce the income losses resulting from increased water tariffs under the EU's Water Framework Directive, at least in Andalusia (Spain).

Source: Adapted from Garrido and Calatrava (2010).

In the case of wetlands, the impact of support and regulatory policies across OECD countries in halting the loss of wetlands to agricultural use was mixed over the period 1990 to 2004 (OECD, 2008a). There was a net loss (restoration minus conversion) of wetlands converted to agricultural use, although at a declining rate of loss over this period in ***France, Italy, Japan, Korea*** and ***Norway,*** but reported net gains of wetlands in the ***Czech and Slovak Republics, United Kingdom*** and the ***United States*** (Box 3.3).

The extension of the area irrigated and some irrigation practices have also led to harmful impacts on aquatic ecosystems in a number of OECD countries. In Australia, nearly 10% of wetlands are affected by salinity, to some extent caused by irrigated farming, but also by the natural presence of salt in the landscape. By 2002 two-thirds of irrigated farms in Australia had changed practices to address salinity issues (OECD, 2008a). For some other countries the extension of the area irrigation and irrigation practices have also had harmful impacts on aquatic ecosystems, such as in **Greece, Portugal, Spain** and **Turkey** (OECD, 2008a).

Research on **Japan,** for example, has shown that modernisation of some paddy systems, including lining waterways and ponds with concrete, field consolidation and removing field interconnections, has reduced the abundance of aquatic species and birds that feed on them (OECD, 2008a). Equally the decline in the area of paddy fields, and lost of its benefits in terms of flood land landslide control, is considered by some researchers to have increased flood and landslide risks in **Japan**.

3.2.5. On-farm water drainage policies and the environment

There has been a significant positive shift in drainage policy across OECD countries since the 1980s. Prior to 1990s on-farm drainage (*i.e.* removal of excess water through surface – *e.g.* ditches or channels – or sub-surface field drainage – *e.g.* networks of pipes, tiles) was viewed in most OECD countries as a farm management area apart, with the aim of land improvement, especially to avoid soil water logging (see the OECD questionnaire at www.oecd.org/water). There was a policy shift, however, from around the early 1990s as increasingly countries begun to combine drainage into an integrated agricultural water resources management approach. For a considerable number of countries support payments for on-farm drainage have ceased since the 1990s (*e.g.* **Austria, Czech Republic, France, Germany, Ireland**).

This policy change was, in particular, driven by environmental demands for the conservation and restoration of wetlands, although for some countries drainage management was also seen as means to achieve other environmental objectives, such as contributing to flood control, avoiding nutrient leakage and soil waterlogging; and preventing soil erosion (see the OECD questionnaire at www.oecd.org/water). The **United States** provides an illustrative example of the evolution of Federal US farmland drainage policies being adapted over recent decades to address environmental concerns, especially wetlands conservation (Box 3.3).

Most OECD countries now place limits to on-farm drainage where it can damage aquatic ecosystems (see the OECD questionnaire at www.oecd.org/water), although drainage of farmland continues to have adverse impacts on aquatic ecosystems in a number of OECD countries. For example, in **Finland**, the loss of open ditches due to the expansion of sub-surface drainage has been harmful to biodiversity, while in **Ireland** drainage, among other factors, has placed pressure on some marginal wetland habitats (OECD, 2008a).

Box 3.3. Drainage of farmland and wetland conservation in the United States

Historically, cropland development and improvement, flood control, water quality improvement, and watershed enhancements for wildlife habitat and recreation were all objectives of US Federal drainage policy. Early U.S. Department of Agriculture (USDA) drainage policy was, as part of a broader federal policy, essentially a "wetlands conversion policy," supporting the installation of surface and sub-surface tile drainage systems to convert wetlands to productive pasture or cropland. The USDA began to support cost-sharing for wetland drainage in 1936, and in 1953 Congress explicitly linked flood control and agricultural drainage under the Federal Watershed Protection and Flood Prevention Act. This Act authorised the USDA to plan and construct watershed improvements, with the USDA providing both technical assistance and cost-sharing of ditches, subsurface drains, and conduits to convey water from fields.

By the late 1970s, after ***significant private and public acknowledgement of the many public-good aspects of wetlands*** (including those for waterfowl and wildlife habitat, ecological, and water quality values) Federal drainage policy began to shift from a "wetlands conversion" policy to a "wetlands conservation" policy. Eventually, with the passage of the Clean Water Act (CWA) and each Farm Bill (starting from 1985) drainage policy evolved into what exists today. This consists of a "wetlands conservation/restoration" policy, supported largely through the USDA's 1990 Wetlands Reserve Program (WRP) and working-lands conservation policies that can support on-farm drainage improvements, but only if they are consistent with the CWA requirements, administrative "no net loss" policy, and the USDA farm programme "conservation compliance" requirements, including the 1985 Farm Act "swampbuster" provisions.[1]

WRP goals are the restoration of high-risk agricultural land located in, or adjacent to, flood-prone areas. Through the fiscal year 2007, the WRP enrolled 1.947 million acres of land, mostly in permanent easements. Expenditures in 2004 and 2005 were about USD 275 million and USD 240 million (at an average cost of USD 1 400 and USD 1 688 per acre) respectively. Average contract size is 194 acres, with much of WRP land in Missouri, Arkansas, Louisiana, Mississippi, Florida, and California. In addition, under the "swampbuster provisions", farm program eligibility can (since 1990) be denied to producers who produce an agricultural commodity on a wetland or convert a wetland in a way that makes the production of an agricultural commodity possible.

Recognising that agricultural activities contribute to hypoxia in the Gulf of Mexico, and that the Midwest includes more than 50 million acres of surface and subsurface drained cropland, USDA in 2003, through its Partnership Management Team, established the Agricultural Drainage Management Systems (ADMS) Task Force to devise an approach to ***improve drainage practices to reduce adverse offsite impacts of drainage waters***. The ADMS Task Force is a joint effort by USDA's Agricultural Research Service (ARS), Natural Resources Conservation Service (NRCS), and the Cooperative State Research, Education, and Extension Service (CSREES), and includes university researchers, extension professionals, as well as scientists from local, state, and federal agencies. The focus of the ADMS Task Force is to work with farmers, contractors, and agricultural advisors to:[2]

- Implement improved agricultural surface and subsurface drainage in both new and retrofitted systems.
- Reduce nitrate loads in drain outflow, a major source of poor stream water quality and hypoxia in the Gulf of Mexico.
- Improve efficiency of production and economic returns through managed surface and subsurface farm drainage.

1. There are numerous studies on the Wetlands Reserve Program: for a selection, see the USDA website at www.ers.usda.gov/Browse/NaturalResourcesEnvironment/
2. For more information on the ADMS Task Force, its charter, vision/goals, objectives and action plans, see www.ag.ohio-state.edu/~usdasdru/ADMS/ADMSindex.htm. For more information about the ADMC, see www.admcoalition.com/.

Source: OECD Secretariat, adapted from the United States government's response to the OECD questionnaire at www.oecd.org/water.

3.2.6. Agricultural support and agricultural water resource management benefits

In some OECD countries agricultural support has been provided on the basis that it can help provide a range of agricultural water resource management benefits (positive externalities). In the case, for example, of **Japanese** and **Korean** paddy rice cultivation under monsoonal conditions these benefits cover the (Box 3.4): environment, such as flood control, water purification and filtration, habitat values such as paddy fields acting as a wetland habitat; rural development, acting as a multiplier on rural incomes and providing ecotourism income through upland paddies providing waterscapes; social outcomes, such as developing community solidarity; and cultural and religious benefits, for example, the cultural identity from the cycle of paddy cultivation (World Bank, 2006).

These environmental benefits need to be weighed against the environmental costs of paddy cultivation systems (*e.g.* methane emissions, chemical runoff). Moreover, the estimated benefits that do flow from support to rice cultivation in **Japan** and **Korea**, involves agricultural support that is significantly above the OECD average.

3.3. Farm management and technology measures

A variety of farm management, advisory and technology approaches are being used by OECD countries to improve agricultural water resource management. For countries concerned with improving on-farm water use efficiency, especially irrigated farming systems, support is widely provided for upgrading irrigation equipment, together with providing farm advisory services and developing research to support irrigators (*e.g.* **Australia, Italy, Mexico, Turkey,** the **United States**) (see the OECD questionnaire at www.oecd.org/water). **Canada** and **France** provide good examples of how countries are seeking an integrated approach to improve water use efficiency in agriculture (Box 3.5).

Promotion of technologies and practices to use on-farm water more efficiently tend to centre on encouraging use of drip emitters and lining irrigation canals. Some practices are geared to enhancing the provision of ecosystem services related to water from agriculture, for example, the use of a network of water corridors in **Japan** and **Korea** linking rivers, paddy rice fields, and irrigation ponds to sustain aquatic biodiversity in these water bodies. Other approaches to encouraging improvements in on-farm water use efficiency include (see the OECD questionnaire at www.oecd.org/water):

- Benchmarking among water suppliers to limit distributional channel losses (**Austria**);
- Establishing an industry code of practice for irrigation system design and use (**New Zealand**);
- Capturing and using rainwater (**Belgium**);
- Developing high water use efficiency cultivars in a wide range of crops to meet increasing drought risks (**Canada, Finland, Italy, Switzerland, United Kingdom, United States**);

- Making greater use of recycled water, including treated sewage and drainage wastewater, and recycling water in greenhouse horticultural systems (**Belgium**); and,
- Exploring the potential of using nanotechnology to improve agricultural water resource management (**United States**) (see Box 3.6).

Box 3.4. Costs and benefits of paddy cultivation systems in Japan and Korea

There have been a number of studies of the positive externalities (multifunctionality) of paddy farming, and Kim *et al. (2006)* list the positive functions as:

- Flood alleviation, due to small irrigation ponds as well as the retaining capacity of bounded rice fields;
- Groundwater recharge, estimated in Korea to be as high as 80% of the rate of surface runoff;
- Water purification of paddy soils acting as nutrient sinks;
- Soil erosion and landslide control on sloped lands;
- Air purification and cooling; and,
- Biodiversity and amenity.

Estimates vary widely as to the value these positive functions, but are generally high, possibly higher than the value of rice produced. In Japan there have been a number of efforts to evaluate the environmental benefits of multifunctionality of paddy fields in Japan (*e.g.* Science Council of Japan, 2001; Yamaoka, 2004).and compensatory payments are made for a limited number of these, such as the use of farm drains by non-farm users and for ecologically beneficial farming. The Japanese Ministry of Agriculture hosts the Secretariat of the International Network for Water and Ecosystem in Paddy Fields (INWEPF), established in 2004, as a forum for those involved in rice growing to network in areas such as giving consideration to multiple uses of agricultural water resources, including environmental aspects (Yamaoka, 2004).

Focus in both Japan and Korea, however, appears to be heavily on estimating multifunctional benefits but these need to be balanced by cost estimates, but valuation of these costs is far less advanced. Kim *et al.* (2006) have described a number of negative externalities associated with paddy farming, such as methane emissions, or disturbance of the ecosystem by land improvement measures such as canal linings and independent drainage canals.

Source: Adapted from Nickum and Ogura (2010), drawing on Kim *et al.* (2006); OECD (2008a); Science Council of Japan (2001); Yamaoka (2004).

There is increasing emphasis being placed in many countries in establishing policy decision support tools to guide agricultural water management strategies (see the OECD questionnaire at www.oecd.org/water). A key element to supporting policy decision making is data collection and monitoring of water resource use in agriculture, including the use of seasonal and inter-annual water balances (accounts/audits) sometimes to provide a national overview of water flows and stocks (*e.g.* **Australia, Greece, Netherlands,** the **United States**) and in other cases as an on-farm tool to help farmers monitor water use on farm and guide their irrigation practices to reduce water use (*e.g.* **Denmark, France, New Zealand, United Kingdom**).

Different ***government*** research agencies provide *research and analysis of water resources in agriculture* to assist policy makers, with increasing focus on the impacts of climate change on agriculture and water resources and projections of future water demand by agriculture (*e.g.* **EU, Korea, Portugal, Switzerland, United Kingdom**) (see the

OECD questionnaire at www.oecd.org/water). *Water planning* is also an important part of the policy tool kit for decision makers, in particular, to assist in the allocation of water resources between agriculture, other water users and environmental needs (Chapter 3.4.2). In this context, **Canada** is one of the few OECD countries to involve public consultation at all levels of government to examine water planning, programmes and targets.

Box 3.5. Improving agricultural water use efficiency in Canada and France

Canada

- Water resource conservation approaches among Canadian jurisdictions are quite variable.
- More emphasis has been placed on efforts to reduce water use in households relative to agriculture and industry.
- Federal government has generally focused its attention on water research, outreach/education, and advancement of technologies and practices.
- Agricultural Policy Framework's National Farm Stewardship Program has provided financial and technical assistance to implement on-farm beneficial management practices.
- Provinces have been more active in this area and have enacted legislation, implemented overarching water strategies/policies, set water use targets, completed awareness campaigns, and a variety of other conservation/efficiency initiatives.
- Improving the efficiency of water use for irrigation is researched and demonstrated at The Canada-Saskatchewan Irrigation Diversification Centre, a partnership between the federal, provincial governments and local organisations.

France

- Introduction of a water abstraction charge.
- Review of licensed volumes, based on actual need and environmental capacity, and enforcement of licensing arrangements.
- Support for adopting water-saving irrigation technologies, such as low-interest credit for purchase of equipment. Support for purchasing equipment (government subsidy not exceeding 40%) under the *Plan Végétal Environnement* (Environmental Crop Production Scheme). Support to purchase metering and management equipment to enhance practices, or specific water-saving equipment (including input control, electronic flow control systems, and rainwater collection/storage).
- Agri-environmental measure to limit irrigation: support to reduce the amount of irrigated farmland.
- Investment support from Water Agencies to create substitute storage and modernise water supply systems (to limit water loss) under the National Rural Development Programme (PDRH).
- Use of farm advisory services, and also support training courses in irrigation, particularly through Chamber of Agriculture networks, although there is no feedback on the scale or impact of these services.

Sources: OECD Secretariat, adapted from the Canadian and French governments' responses to the OECD questionnaire at www.oecd.org/water.

Box 3.6. Potential of nanotechnology for improved water management in agriculture

Nanotechnology: "... the understanding and control of matter at dimensions of roughly 1 to 100 nanometres, where unique phenomena enable novel applications…" (US National Nanotechnology Initiative). "… Utilising the properties of nanoscale materials … to create improved materials, devices, and systems …" (ISO TCC 229). One nanometre is one millionth of a millimetre.

The nanotechnologies being used in agriculture involve carbon nanotubes, nano-cantilevers, nanoparticles, nanosurfaces and nanosensors. They can be applied in diagnostics; in detecting parasites and bacteria; encapsulation and controlled release of herbicides, pesticides and drugs; for grass growth regulation; and, of course, for water management and sensing.

Precision farming is increasingly using satellite-positioning systems (GPS), geographic information systems, automated machine guidance and remote sensing devices. Researchers are working to improve these systems – their accuracy and response rates as well as their size and robustness – through the use of nanotechnology. Water management in agriculture can be significantly improved in the future through the effective application of such emerging technologies.

Currently, wireless nanosensors are facilitating intensive sensing of environmental conditions to control the automated application of water, as well as fertilisers and pesticides. Sensing drought through nanosensors, levels of irrigation are automatically adjusted in the field in real time, making for more effective and efficient water use for better crops and lower costs. Likewise, sensors using nanotechnology can be fitted to combine harvesters to measure the amount and moisture levels of grains being harvested on different parts of a field, generating computer models which guide decisions about the application or timing of water inputs.

Industry is already applying wireless sensor networks in agriculture, combining electronic chips with nano-scale features into wireless networks of "motes" (i.e. miniature, self-contained, battery-powered computers with radio links: motes can self-organise into networks, communicate with each other and exchange data). Motes can be used on the farm for irrigation management, frost detection and warning, pesticide application, harvest timing, bio-remediation and containment, and water quality measurement and control.

Installed in vineyards in Oregon and California, United States, sensors measure the soil temperature once every minute but can equally be applied to measuring moisture levels and determining the need for irrigation. Networked sensors scattered on fields can also provide detailed data on crop and soil water content and relay that information to the farmer. As nanotechnology developments lead to better and cheaper sensors, this technology may be more widely applied.

Source: OECD Secretariat, drawing on a project on *Global Challenges: Nanotechnology and Water,* OECD, forthcoming, 2010.

3.4. Water policies and agriculture

3.4.1. Overview

For most countries up to the early 1990s water management related to agriculture largely focused on the supply of water, with emphasis on infrastructure, technical solutions and harvesting the maximum amount from the resource, within a command and control institutional structure (Hamstead *et al.,* 2008; Pahl-Wostl, 2008). This "hard" technology based and centralised path to capture and deliver water to agriculture is now being complemented by a path with a shift to the sustainable use of water. The emphasis here is on: meeting diverse demands for water (*i.e.* economic, environmental and social) to match user's needs; embracing participatory and collaborative decision making and institutional structures; and encouraging a greater role for market mechanisms (Pahl-Wostl *et al.,* 2008).

The shift from the "hard" to the "soft" path of water management and governance has reflected a number of developments over the past two decades, including:

- Greater focus on attaining environmental objectives, such as water conservation and pollution control to limit adverse impacts on ecosystems;
- Recognition that economic instruments, such as water pricing, can help cover the financial costs of irrigation systems and improve water use efficiency in situations of water scarcity;
- Pressure on governments to control budgetary expenditure on costly technical solutions to providing water to agriculture;
- Concern to develop management and governance systems that can address the uncertainties induced by climate change impacts on water resources;
- Decline in long-run "real" agricultural commodity prices over many decades has made it difficult to justify major expenditure in "new" irrigation facilities; and,
- Increased attention on moving from national and state control of water policy to a more decentralised, participatory and integrated forms of management and policy decision-making, to encourage the involvement of all stakeholders in a water basin and better address local economic, environmental and social needs (Box 3.7).

Box 3.7. Institutional organisation for agricultural water resource governance across OECD countries

The ***institutional frameworks governing water management across most OECD countries,*** within which water in agriculture is managed and allocated across competing demands, can be broadly characterised as follows, although there are some marked differences from this description (see the OECD questionnaire at www.oecd.org/water):

- *National/Federal level of government:* Ministries of Agriculture, Environment, Infrastructures, etc., have overall but split responsibilities for determining policy objectives and targets for water resources (where appropriate), involving co-ordination across Ministries and sub-national layers of government (see below). In most countries these responsibilities extend to monitoring and research activities, control of regulatory arrangements, especially governing groundwater, and also transboundary water resource issues.
- *Provincial/Regional/State level of government:* Water resource planning and management functions are usually conducted at this level, although this is generally organised in terms of jurisdictional (State/Provincial) boundaries (*e.g.* **Australia, Canada, Japan,** the **United States**) some countries also organised water resource management through Regional Water Management Boards which may be in control of one or several water basins (*e.g.* **Greece, Italy, Mexico, Poland, Spain**).
- *Water basin (or water catchment) authorities:* These authorities are typically involved with managing water rights, licences for water abstract and financial control (*e.g.* collecting and determining water charges) and inspection of irrigation infrastructure.
- *Water user associations/co-operatives:* Water user groups operate usually at the sub-basin level, involved with the day to day management responsibilities of the irrigation system.

Source: OECD Secretariat, based on responses from member countries to the OECD questionnaire at www.oecd.org/water.

3.4.2. Water policy reforms and the agricultural sector

The shift in policy focus with a greater accent on demand rather than supply management policies has brought reforms to the institutional and governance structure managing water resources. The evolution and key elements in water policy reforms across OECD countries and important to agricultural water resource management are summarised in this section, drawing on the OECD questionnaire at www.oecd.org/water.

The progress and path of water policy reforms has been mixed. Over the past decade some major changes in water resource policies have taken place, for example in **Australia, Mexico** and **Turkey** (Box 3.8). The **European Union** has also embarked on an ambitious programme of water reform through the *Water Framework Directive* (WFD) which came into force in 2000. EU member states have now transposed the WFD into national law as the overarching framework guiding each member state's water policy, with the key dates for the national implementation of the WFD including finalising river basin plans (2009); introducing pricing policies (2010); meeting environmental objectives (2015); and finalising implementation of the WFD (2027).

The United States does not have a comprehensive national water policy, and water resource policy is essentially pragmatically managed at the State level, with a general trend towards increased use of water markets, water banks and per-unit water pricing. Some countries are only just beginning to embark on a process of water policy reforms (*e.g.* **Canada** and **New Zealand**), and it is too early to make assessment of these policies. In other cases progress in reforming policies has been more limited (*e.g.* **Japan, Korea**), with some change in focus on environmental issues and some reorganisation of the institutional structure governing water. There are plans, however, in many of these countries to consider developing water markets, water pricing or using other more market-based policy instruments to manage water resources (see the OECD questionnaire at www.oecd.org/water).

The institutional arrangements governing water management in OECD countries remains multifaceted and multilayered. This structure results in practices and regulations that are complex and differ regionally, even at the level of water basins, reflecting varying political systems, histories and cultures not only across OECD countries but within them. **Mexico** provides an illustration of this complex structure with overall national planning under the National Water Commission (NWD), with involvement of other Federal Ministries (Agriculture, Environment and Irrigation Agency), and power of the NWD devolved to 85 Irrigation Water Basin Districts located in 30 States (which also have some interest and involvement in water management), which in turn co-ordinate with nearly 500 Water User Associations which deliver water to farmers individually and farmer co-operative.

Even in situations where reforms to water institutions and policies have been very rapid over recent years, for example **Australia,** there are significant regional variations even within States such that there can be dozens of water supply schemes, some with different owners, and varying water pricing structures and tariffs (Parker and Speed, 2010). But some countries, for example **Spain,** have created a single Water Authority and streamlined the institutional arrangements to manage water resources.

Box 3.8. Water policy reforms and agriculture: Experiences of Australia, Mexico and Turkey

Australia

Australia has embraced the idea of competition and markets as a paradigm for water management. The establishment of a nationally consistent water entitlement and trading system is providing security to both water users and the environment in Australia. Water trading allows scarce water resources to be transferred to their most efficient and productive uses, and is being delivered through a range of State and National initiatives. The result has been the generation of significant opportunities to achieve sustainable and efficient water use. The development of water markets is seen as a key mechanism, along with planning and appropriate regulation, to address over allocation of water resources whilst optimising the economic, social and environmental outcomes in Australia. This integrated approach will also assist to adapt to changing water availability in the face of a climate change.

Underpinning the Australian experience is a suite of institutional and property right reforms that have made it easier to set up viable water markets. The general model is one that has involved development of a water entitlement regime that allows people to own the right to use water. State governments' legislation makes it clear that water is controlled by the State on behalf of the general public. Water users may only acquire or hold an entitlement to use water that is available according to a statutory water plan. Moreover, it is the role of governments rather than the courts to determine how much water is available for use. The result is a property right regime that is conducive to the development of efficient markets. In general the rights to use water is 'unbundled' into a three part structure:

- The ***entitlement*** is a proportionate share of water as specified in a water plan. This entitlement is separate from any land title and may be traded among any willing purchasers. These are referred to as permanent trades.
- Decisions on ***volumetric allocations*** are made on an ongoing basis throughout a water year. The allocation is made to an entitlement and recorded in the water account associated with the entitlement. Allocation trades, or temporary trades as they are called in Australia, can then be made by debiting one account and crediting another. Allocations are not linked to land titles. These annual allocations may be traded among willing purchasers.
- ***Use approvals*** then set out the rules for applying water to a nominated area of land and deducting the amount used from a water account associated with the use approval. Site use approvals are not generally tradable as the conditions relate specifically to a piece of land.

In the face of worsening climatic conditions in eastern and southern Australia and difficulties in rebalancing the amount of water in the environment pool versus the consumptive pool and addressing institutional weaknesses, the Federal Government announced Water for the Future in 2008. Water for the Future is a AUD 12.9 billion investment over 10 years with overarching objectives to take action on climate change, use water wisely, secure water supplies and support healthy rivers and waterways. Investment is being mainly used to purchase water entitlements for the environment and infrastructure upgrades and reconfiguration, with water savings being returned to the environment on a shared basis.

Water information is critical to the effective operation of water markets, and is vital to underpin and build confidence in all aspects of sustainable water planning and management. ***Under Australia's*** national Water Act 2007, the Federal Bureau of Meteorology is authorised to collect and publish high-quality water information. The publications will include an annual National Water Account and periodic reports on water resource use and availability. The Bureau is also empowered to set and implement national standards for water information.

Complimenting Water for the Future, the Council of Australian Governments agreed in November 2008 to a number of initiatives to improve the operation of water markets and trading through faster processing of temporary water trades, and to co-ordinate water information and research through the development of a national research plan and water modelling strategy. Australian experience with water reform suggests that investment returns well in excess of 15% per annum are achievable. In May 2009, Water Ministers approved trading standards for permanent water trades.

Mexico

Since the passing of the Water Law in 1992 and the creation of the National Water Commission, Mexico has embarked on a major policy reform to devolve water management of its large water districts to Water Users Associations (WUAs). This has involved setting new institutions such as basin agencies, giving WUAs managing capacity to administer both capital assets and water resources, and transferring the financial responsibility of running districts and collecting charges to the WUAs. Research has shown that between 1990 and 1996 government water subsidies and tariff deficit had gone down to 15% and 13% respectively, from 35% and 26%. By 1996, 372 WUAs had been formed to control water delivery to nearly 3 million ha. During this time water prices increased by 45–180% and government operation and maintenance (O&M) subsidies had been removed, but some researchers claim that O&M charges are too low (equivalent to 2-7% of the gross product), and that maintenance may be suboptimal in many cases.

Overall water policy reforms have helped toward improving water use efficiency and reducing losses and there has been some improvement in irrigation water application rates per hectare irrigated. But subsidies for water charges and electricity for pumping are undermining the efforts to achieve sustainable agricultural water use and, in the case of energy, reduce greenhouse gas emissions. There is also concern that the subsidy to electricity is also exacerbating the pumping of groundwater and the growing overexploitation of this resource above recharge rates. Moreover, the irrigation and electricity subsidy appears to be in contradiction to the new programme to purchase water rights from farmers, raising the costs to the government of achieving their environmental objectives.

Turkey

The costs of irrigation systems are being transferred from the government to local water user associations. With the progressive transfer of the operation and maintenance (O&M) of irrigation networks from the government General Directorate of State Hydraulic Works (DSI) and General Directorate of Rural Services (GDRS) to self financing local water user associations, farmers are supporting a higher share of the costs of maintaining irrigation systems. The DSI is mainly responsible for the development and maintenance of large irrigation infrastructure (*e.g.* dams, drilling wells), while the GDRS largely develops small scale on-farm irrigation works.

Farmers partially cover O&M costs of irrigation water through annual crop and area based charges. While collection rates of water charges in publicly operated schemes are low and never exceed 54%, those in farmer operated schemes are almost 90%. The DSI expenditure on irrigation O&M costs (net of farmer's fees) averaged TKY 103 (USD 75) million over 2004 and 2005. In recent years water charges have risen, as a result of the transfer of irrigated areas operated by the DSI to water user associations. A study of cotton and grape production in the Gediz Basin, for example, showed that where these transfers have occurred and water charges increased, irrigation water productivity showed significant gains.

Some regional development projects have significant implications for agriculture and the environment. Many of these projects are financed by international development agencies and donors (*e.g.* the World Bank), as national funding is limited. The South-Eastern Anatolian Project (GAP) (1983-2001), which was financed mostly by national resources, is the largest regional development project in Turkey covering 10% of the total land at an estimated cost of TKY 50 (USD 32) billion. GAP involves, among other objectives, to expand agricultural production in the region through building 22 dams and providing irrigation infrastructure for 1.7 million ha of land by 2015. For the World Bank- funded Anatolian Watershed Rehabilitation Project (DOKAP), with funding of TKY 65 (USD 45) million over 2004 to 2012, the aim is to restore degraded soils to increase farm and forestry production. But some major irrigation projects, such as the GAP, have also been undertaken with little consideration of environmental management or impacts, with the loss of valuable ecosystems (*e.g.* steppe, wetlands) and increasing problems of salinity and agro-chemical runoff becoming widespread. Even so, the GAP project is increasing the supply of domestically produced hydroelectricity and has brought socio-economic welfare gains to villagers.

Overall the continued subsidies for water charges and electricity for pumping are undermining the efforts to achieve sustainable agricultural water use, especially groundwater. The operation and management responsibilities for local irrigation networks (previously run by a national monopoly), however, have been transferred to self-financing water user associations. This has led to an increase in water charges in order to cover operating costs and is helping toward more effective use of scarce water resources. This pricing scheme may be appropriate as an agricultural policy targeted to increase the income of the farmers and boost the contribution of agriculture to the overall development. However, the water pricing approach used in Turkey disregards several factors that may improve the performance of the agricultural sector and possible externalities that may arise because of irrigation development. Volume independent price may cause overuse of water with a negative impact on the yields of irrigated crops even if water is abundant. Water allocation problems will arise within agriculture and pressure for intersectoral transfers of water will augment when water is scarce. Irrigation related environmental externalities will further create social and economic costs.

Sources: Adapted from Young (2010) (Australia); Garrido and Calatrava (2010) (Mexico); Cakmak (2010) and OECD (2008a) (Turkey).

There has been a shift towards decentralisation of institutional arrangements concerning water governance, from national/regional governments levels to one encouraging greater local engagement and involvement of water users in resource management in agriculture. Over many decades the **United States**, for example, shifted water policy from mainly major Federal water development projects to a highly decentralised pragmatic form of management at State and sub-State level (Deason *et al.,* 2001; Gerlak, 2008). A key element under the **EU's** *Water Framework Directive* is to move member states towards a river basin management planning (RBMP) system, with all member states having to finalise their RBMPs, including a programme of measures, and then updated every six years (2015).

Some countries have begun to embrace the idea of competition and water trading as a paradigm for water management. So far development of water markets and water trading arrangements are limited across OECD countries (*e.g.* **Australia, United States**). Even in countries where the progress in developing water markets is more advanced, such as **Australia**, trade in water and water access entitlements has been small, such that during 2004-05 only 7% of total water consumption and 4% of water entitlements were traded (Parker and Speed, 2010; Young, 2010). A number of countries are beginning to evaluate the possibilities of developing water markets (*e.g.* **Canada, New Zealand**), but in other countries (*e.g.* **Austria, Belgium, Japan, Portugal**) the possibility of developing water markets are hindered by a combination of publicly owned water rights, water entitlement law and government regulations (see the OECD questionnaire at www.oecd.org/water).

While in principle there are no reasons in most OECD countries why water markets (*i.e.* trading of water entitlements) cannot be established, ***impediments to water market formation*** remain mainly because of the:

- Incomplete understanding of the science of water resource and ecosystem linkages;
- Lack of physical interconnecting networks between water delivery systems supplying agriculture, urban, industrial and other users;

- Uncertainty about the supply and demand for water at a given point in the future;
- Poorly defined property rights, including problems over separating land from water entitlements;
- Defining, securing and agreeing among stakeholders the quantity of water needed in a water basin to sustain environmental values;
- High transaction costs in creating water markets;
- Issues of equity in that water markets are perceived to ignore the poor, and that they are also largely considered to focus on economic efficiency overlooking environmental and social considerations; and, that in
- Many circumstances irrigators do not have the opportunity to trade their water entitlements with other users as no markets exist to do so.

The transfer of water from potential agricultural use to meet environmental needs is, however, becoming more widespread (*e.g.* **Australia,** Box 3.8). This is being achieved mainly through the use of regulatory policy instruments (*e.g.* abstraction licences – see the OECD questionnaire at www.oecd.org/water), as part of the water allocation process. The use of minimum river flow standards, is employed by some countries to ensure environmental water used for maintaining ecosystems (*e.g.* **Australia, Japan, Korea, Norway, Spain, Switzerland,** the **United States**), with more rivers expected to be subject to minimum instream river flows in **EU** member states under the *Water Framework Directive* (see the OECD questionnaire at www.oecd.org/water).

Intersectoral transfers of water between agriculture and other users is infrequent, and mainly occurs in extreme cases of drought for urban users, in which case government's usually has the right to revoke private water rights in the public interest. Some States in the **United States,** for example, have assisted farmers and other water users in obtaining water during sustained droughts by creating centralised water banks in which buyers and sellers can exchange information and conduct transactions (Wichelns, 2010b).

Regimes for groundwater rights are generally less developed compared to surface water (see the OECD questionnaire at www.oecd.org/water). User right systems are also frequently unco-ordinated between groundwater and surface water. Typically the landowner (farmer) is given the exclusive right to extract from groundwater beneath their property, although most countries have introduced regulations to limit private extraction from commonly shared groundwater resources and landowners will normally require consent from a government agency prior to making extractions. The conditions attached to a water permit/licence to extract groundwater (or surface water) can be extremely detailed, such as highlighted by the example of **New Zealand's** system of water permits (Box 3.9). Some states in **Australia** have more advanced water rights regimes for groundwater, involving water entitlement licences (which might only be issued for 5 to 10-year periods), annual allocations and trading in groundwater (see the OECD questionnaire at www.oecd.org/water).

Box 3.9. Conditions attached to water permits in New Zealand

Water permits are limited use rights, constrained by conditions set by the consent authority (for a water permit this is the regional council or unitary authority). Under section 14 of the national Resource Management Act (which was established in 1991 and is the key national legislation governing management of freshwater resources in New Zealand) extracting water from rivers, lakes and aquifers must either be authorised by consent or qualify as a permitted activity in a water plan. This excludes the extraction of drinking water for livestock and domestic purposes, which are specifically permitted by section 14.

Conditions attached to a water permit consent may include:

- The location(s) of the point of extraction or diversion.
- The ultimate use of the water.
- Volumetric controls on the rate of take (instantaneous, daily, weekly, monthly, seasonal, annual).
- Land titles (or designated areas) over which the consent may be utilised.
- Controls on the technical or physical efficiency of water use.
- Specification of environmental compliance monitoring requirements.
- Implementation of controls or restrictions on the exercise of the consent.
- Provisions to enable review of the consent.

Source: New Zealand government's response to the OECD questionnaire at www.oecd.org/water.

3.4.3. Agricultural water charges and cost recovery: Surface water and groundwater

Surface water

Water charges across most OECD countries usually involve a mixed system of a fixed charge and a volumetric charge above a certain threshold for surface water (Box 3.10 and the OECD questionnaire at www.oecd.org/water). Per-hectare water charges (flat rate) are widely used for gravity fed irrigation systems across OECD countries. Flat rate charges per hectare are perhaps the most adverse incentive affecting irrigators' use of surface water, especially where water stress is an issue. Hence, the extent of using volumetric water charges in agriculture is highly variable across OECD countries. For example, in **France** by 2005 over 70% of farms and 85% of the area irrigated were equipped with volumetric devices, while from 2006 it became obligatory for farmers to install volumetric meters. In Japan, however, less than 1% of the 6 000 irrigation districts (Land Improvement Districts) use volumetric charges (see the OECD questionnaire at www.oecd.org/water).

Numerous obstacles hinder progress in replacing flat rates with volumetric rates (Garrido and Calatrava, 2010), including the high transaction costs of installing, implementing and monitoring volumetric charges in large scale irrigation projects. Research by Tsur and Dinar (1997) illustrates how the efficiency gains may not justify the costs of restructuring tariffs, while Chakravorty and Roumasset (1991) and Hafi *et al.* (2001) show that volumetric charges could have wealth re-distributional effects in large districts with network losses.

There are significant variations in surface water charges for farmers not only across OECD countries, but between regions and different water basins within regions. This reflects to some extent the variety of water rights, allocations, and contractual arrangements that characterise water use across OECD countries (see the OECD questionnaire at www.oecd.org/water). In **Spain** (Table 3.2) and the **United States,** for example, there is a wide range in the charges paid for irrigation water.

Some farmers in the **United States,** with riparian water rights or exchange agreements with the federal government, receive water at very low cost (USD 5 to USD 10 per 1 000 m^3), while other farmers with less favourable contracts or those who purchase water from some state-level irrigation agencies pay much higher prices (ranging from USD 20 to more than USD 100 per 1 000 m^3). Farmers purchasing water in market transactions to finish an irrigation season or to ensure water supply for perennial crops might pay prices that exceed USD 100 per m^3 for a portion of their irrigation supply (Wichelns, 2010b).

Box 3.10. Water charges, tariffs, prices and markets: A note on terminology

- ***A water charge*** can be defined as an actual financial payment by users to access water. It is equivalent to a ***water tariff*** a term commonly used in the domestic/urban water sector when differential charges are set. Sometimes the term water charge is replaced by the term irrigation service fee, as the term charge is disliked by some policy makers as it suggests water is taxed.
- ***The main types of water charge mechanisms*** include (FAO, 2004; Molle and Berkoff, 2007a):
  a. ***A flat rate or fixed charge,*** based on the nature of the supply contract. The most common form of charging is based on land area, as this is easy to administer and suited to continuous flow irrigation, such as gravity fed systems and canal irrigation.
  b. ***Volumetric supply charge*** is based on actual water diversions to a user or group of users (bulk water pricing), and requires some form of water metering, which can include:
     1. "Block prices", fixed for different levels of consumption; and,
     2. "Mixed tariffs", which combine a flat rate (usually area based) with a volumetric price, providing stable minimum revenue to the water provider and a variable charge according to use.
- ***The price of a unit of water*** is defined as the price set by the market, in a given political and social context, to ensure cost recovery, equity and sustainability and which may or may not include subsidies. By understanding the full long run and short run opportunity cost of water this should provide the context for establishing water markets, pollution charges and incentives for pollution control or increasing positive externalities.
- ***Water markets*** involve transactions in water between users and water providers affected by supply and demand. Water entitlements (allocations) can be traded, within season, seasonally or permanently, or where the market is regulated the regulator can set the price, price limits, and serve as a broker, for example, to facilitate market operation. The market price of the entitlements to receive water, is a price for allocating water and a price to determine the share of the water available.

Sources: Adapted from Molle and Berkoff (2007a); FAO (2004).

Table 3.2. Operation and Maintenance Costs and Recovery Rates for irrigation water services in Spain

Euros (only in the inter-regional basins)

Basin	Groundwater		Surface			Total		% Operation and maintenance cost recovery rates
			EUR per ha					
	EUR per ha	EUR per m³	Distribution	ID and Basin tariff	EUR per m³	EUR per ha	EUR per m³	
Duero	500	0.095	19.88	46	0.012	231	0.044	89
Ebro	829	0.15	49	12	0.011	113	0.020	86
Guadalquivir	744	0.15	101	70	0.035	400	0.081	98
Guadiana	232	0.048	19	102	0.025	188	0.039	54
Júcar	383	0.074	81	16	0.02	283	0.055	85
Segura	789	0.163	34	151	0.038	464	0.096	n.a.
Tagus	541	0.1	36	67	0.02	199	0.038	n.a.
TOTAL	**500**	**0.09**	**50**	**56**	**0.021**	**263.5**	**0.051**	**87%**

n.a. : not available

Source: MMA (2007).

Korea also has a wide range of irrigation charges (Table 3.3), and operates a dual system of full support for major irrigation schemes (excluding mandatory labour levies) and no support for smaller schemes. This is asymmetric in terms of water management and may be deleterious to the small irrigators, who must cover the full supply costs for water supplies. At the same time, farms within the major irrigation schemes ("superior" farms) are legally restricted to cereal production, while farmers operating under smaller irrigation schemes are not so constrained in their production options (Nickum and Ogura, 2008).

Depending on the regulatory and institutional setting, ***full supply costs of surface water delivered to the agricultural sector on-farm*** (operation and maintenance, plus capital renewal and new capital costs) are usually those costs covered at the level of the: private irrigator (*e.g.* water charges for water delivered on-farm); irrigation district or water user association (*e.g.* operating and maintaining the irrigation capital infrastructure); and state or water authority (*e.g.* renewal and investment costs associated with the construction of irrigation infrastructure).

Full recovery of operation and maintenance (O&M) costs for water supplied to agriculture but low capital cost recovery is common for most countries (Figure 3.1 and the OECD questionnaire at www.oecd.org/water). For those countries where there is full supply cost recovery (O&M and capital costs) for surface water delivered to farms, none have large scale irrigation projects, with most irrigation networks privately owned.

Table 3.3. Average irrigated association charge on farmers by region in Korea, 2005

Unit: USD/ha	Average	Highest	Irrigated paddy field ('000 ha)*
National average	**31**	**387**	..
Incheon- gwangyeoksi	45	75	8
Gwanju-gwangyeoksi	36	247	8
Gyeonggi-do	30	185	80
Gangwon-do	19	103	38
Chungcheongbuk-do	24	78	50
Chungcheongnam-do	54	387	139
Jeollabuk-do	85	156	128
Jeollanam-do	32	59	151
Gyeongsangbuk-do	24	68	135
Gyeongsangnam-do	26	222	98

.. : not available

Data show the range of Irrigation Associations (IA) charges on Korean farmers for irrigation by region. The average varies substantially, from USD 19/ha in mountainous, little-irrigated, north-eastern Gangwon-do, to USD 85 ha in south-western Jeollabuk-do, with a substantial area of irrigated paddy.

* Data for 2006.

Source: Adapted from Nickum and Ogura (2010).

Where irrigation plays a more significant role in the agricultural sector and there has usually been a history of major publicly funded irrigation projects, more rapid progress is being made to recover capital costs from farmers (*e.g.* **Australia, France** and the **United States**). But the recovery of capital costs for irrigation costs, even for these countries, can be highly variable (*e.g.* in **France** 15-95% of capital costs recovered depending on the water basin). However, in the case of major projects of irrigation infrastructure rehabilitation, modernisation or refurbishment, urban/industrial water consumers (through cross-subsidisation) and taxpayers in most OECD countries continue to bear the main share of the capital costs, with public agencies managing the water delivery systems. Even so, water service infrastructure for urban and industrial water users is also frequently publicly financed (OECD 2009a).

Rates of cost recovery for water supplied to agricultural are increasing for most OECD countries. Evidence from studies of EU member states (Garrido and Calatrava, 2010), the **United States** (Wichelns, 2010b), **Australia** (Parker and Speed, 2010), **Mexico** (Figure 3.2; Garrido and Calatrava, 2010) and **Turkey** (Figure 3.3; Cakmak, 2010) all confirm this trend. Concerning the EU, under the *Water Framework Directive* (WFD) member states from 2010 will be required to ensure that the water prices charged to all consumers reflect the full costs (O&M + capital costs + environmental and resource [opportunity] costs, Figure 1.4), although derogations will be possible for less-favoured areas or on grounds of social welfare to ensure all consumers have a basic service (see the OECD questionnaire at www.oecd.org/water). **Australia** also expects that some States will reach full cost recovery for irrigation water by 2010 (*e.g.* New South Wales).

Figure 3.1. Full supply cost recovery[1] for surface water delivered on-farm across OECD countries,[2] 2008[3]

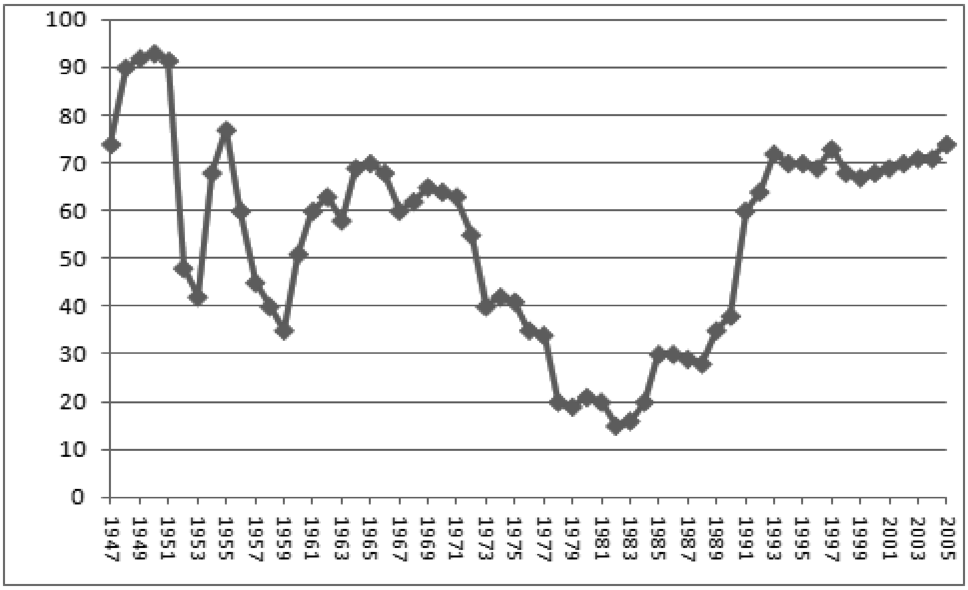
- **100% cost recovery of Operation and Maintenance and Capital Costs:**
  Austria; Denmark; Finland; New Zealand; Sweden; United Kingdom
- **100% cost recovery of Operation and Maintenance Costs, but less than 100% recovery of Capital Costs:**
  Australia; Canada; France; Japan; United States
- **Less than 100% cost recovery of Operation and Maintenance and Capital Costs:**
  Greece; Hungary; Ireland; Italy; Mexico; Netherlands; Poland; Portugal; Spain; Switzerland; Turkey
- **Less than 100% cost recovery of Operation and Maintenance Costs, with Capital Costs supported**:
  Korea
- **Recovery of other costs through water charges or water pricing: Opportunity costs, economic and environmental externality costs:[4]**
  - Australia, some environmental costs already recovered, but planned to recover opportunity costs; economic and environmental costs by 2010;
  - France, is recovering a share of the environmental costs through water charges;
  - United Kingdom, currently recovering share of environmental costs.

1. This is equivalent to the full supply costs shown in Figure 1.4, *i.e.* operation and maintenance costs and capital costs (renewal and new costs).
2. No information is available on the following OECD countries: Belgium; Czech Republic; Germany; Iceland, Luxembourg, Norway, Slovak Republic.
3. This figure summarises the information from the OECD questionnaire at www.oecd.org/water.
4. Other costs including opportunity costs, economic and environmental externality costs are shown in Figure 1.4.
Source: OECD Secretariat, based on responses from member countries to an OECD questionnaire at www.oecd.org/water.

For **Japan**, however, there has been little change in the rate of cost recovery for irrigation water supplies, while for **Korea** cost recovery rates have been declining for more than a decade (Nickum and Ogura, 2010). **China** (although not an OECD member country) has embraced, but not always implemented, market principles for water cost recovery in agriculture (Nickum and Ogura, 2010).

There have been major increases in water charges for irrigation water supplies in **Australia** since 1994, and increasing acceptance amongst irrigation customers of the logic of, and need for, charges to recover "lower bound" costs (*i.e.* water charges cover the operation, maintenance and renewal capital costs of supplying irrigation water) (Table 3.4, and Parker and Speed, 2010). However, "lower bound" pricing can mean improvements in service standards are small. Capital for significant scheme efficiencies and improvements require either increases in water charges toward "upper bound" (*i.e.* full supply costs, including financial, externality and opportunity costs), or capital support to realise efficiencies. The Federal government has recently provided capital support to some of the larger irrigation schemes to increase efficiency, with the intent that volumes of water saved are returned to the environment (Box 3.8).

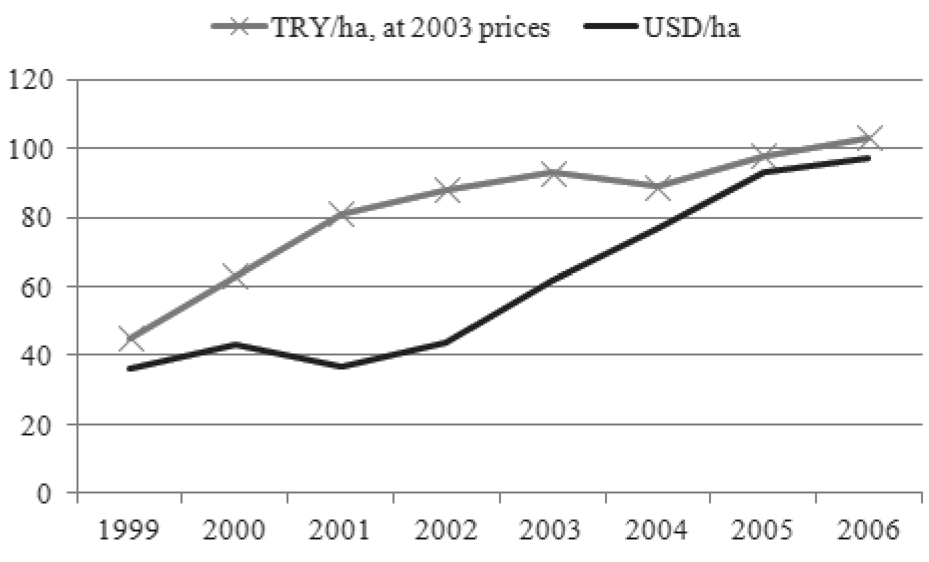
Figure 3.2. Recovery rates for Operation and Maintenance costs in irrigated areas in Mexico



Source: Garrido and Calatrava (2010), adapted from Silva Ochoa and Garcés-Restrepo (2002).

Figure 3.3. Average Turkish irrigation Operation and Maintenance charges, 1999-2006

(TRY/ha, at 2003 prices and USD/ha)



Source: Cakmak (2010).

Table 3.4. Cost recovery rates for irrigation water in Australia

	Volume of irrigation water supplied (megalitres)	**Share of cost recovery** (%)
New South Wales	4 777 604	88
Queensland	1 206 725	97
Victoria	1 192 983	100
Total of above States	**7 177 312**	**91**

Cost recovery is defined as including: the operation, maintenance and renewal capital costs of supplying irrigation.

Source: Adapted from Parker and Speed (2010).

Water authorities are beginning to recover the opportunity (resource) costs and environmental and economic externality costs associated with water use in agriculture, but this applies to only a very few countries (Figure 3.1 and the OECD questionnaire at www.oecd.org/water). These costs, however, are sometimes recovered through other policy instruments, such as the use of water pollution taxes in **France** (Table 3.5), **Belgium** (pollution tax); Portugal (from 2008 tax on water users to cover economic and environmental costs); or where agriculture provides positive environmental externalities, such as conservation of wetlands, then payments are paid to farmers for maintaining this public good (see discussion above, Chapter 3.2.3 and 3.2.4).

Greece has made a comprehensive calculation of water demand and the full cost and cost recovery of water services for agriculture and other water users (Box 3.11). This calculation has been made as part of Greece's submission under the **EU** Water Framework Directive.

For most OECD countries quotas, allocations, licences, or annual entitlements are the usual allocative mechanisms between different water users or for environmental needs. The use of water markets and trading water entitlements to allocate water is only practised in a very limited number of OECD countries (*e.g.* **Australia**). In effect the opportunity (resource) cost of water used by agriculture is implicit in the use of quotas, licences, permits and other rationing mechanisms used by policy makers.

Table 3.5. Water taxes for irrigation charged by the *Agences de l'Eau* in France

Water basin authorities	**Average tax** (2002, EUR/m^3)	**Minimum-maximum** (2003-06, EUR/m^3)	**Abstracted volume** (million m^3, 2002)
Adour Garonne	0.0047	0.0026 – 0.0057	758
Artois Picardie	0.0134	0.0012 – 0-0609	15
Loire Bretagne	0.0066	0.0044 – 0.0175	499
Rhine Meuse	0.0014	0.0013 – 0.0015	77
Rhone Méditerranée	0.0015	0 – 0.0027	1643
Seine Normandie	0.0171	0.0051 – 0.0192	95

Source: Garrido and Calatrava (2010), drawing on Rieu (2006), using data from the *Agences de l'Eau.*

Considerable caution is required in using and comparing data on cost recovery rates and agricultural water charges, both within and between countries. In particular, difficulties relate to (Garrido and Calatrava, 2010; Nickum and Ogura, 2010):

- Lack of transparency in data concerning financial costs for supplying water, especially concerning capital costs. A simplification of the water pricing and cost-sharing systems on a system-wide basis would improve transparency and make it possible to establish more precise estimates of how much of total irrigation capital costs are covered by central and local governments as well as farmers;
- Many water distribution networks and storage facilities are often shared with multiple users, including agriculture, so allocating financial costs to different water users is complex;
- Major publicly funded irrigation projects can be implemented over many decades in a piecemeal fashion, making accountancy of the projects difficult; and,
- Evaluating replacement costs over the life cycle of a dam or reservoir can be complex.

Groundwater

As discussed in the previous chapter, the landowner (farmer) is usually given the exclusive right to extract from groundwater beneath their property. The use of regulatory instruments, however, is widespread across OECD countries in an effort to achieve sustainable use of commonly shared groundwater resources. Typically most countries apply a fixed fee and volumetric charge extraction groundwater were the resource is shared with other users, although **Turkey** uses a per hectare (flat rate) charge, while **Japan** and **Korea** have no charges for extracting groundwater (see the OECD questionnaire at www.oecd.org/water).

Irrigation costs have been increasing in many regions of OECD where farmers rely on limited supplies of groundwater. Moreover, increases in the price of energy for pumping groundwater coupled with declining groundwater levels has motivated farmers to improve their irrigation practices and increase the values they generate per unit of water extracted from groundwater resources.

This situation is well illustrated by the High Plains of Texas and other regions of the **United States** served by the fossil Ogallala Aquifer (Box 3.12). Several states have established groundwater management districts and limited the development of new wells, in an effort to slow the rate of depletion in a largely agricultural region that depends on irrigation. Some states also require farmers to measure and report the volume of water they withdraw from the aquifer each year, thus generating helpful data for state agencies, while also increasing farm-level awareness of the rate of aquifer depletion in the region.

Box 3.11. Measurement of full cost recovery in Greece

As part of the Greek Final Report for Article 5 of the EU's Water Framework Directive, the government has established official data for water consumption, cost of water services and level of cost recovery for the 14 Greek water regions (see Tables 3.6 and 3.7 below: for the regional data, see Source below). The different categories of costs shown in the tables below have been determined as follows:

- The ***financial (supply) cost*** was taken from the annual financial reports of the companies providing water for both domestic (DEYA) and irrigation (TOEB) purposes.
- The ***resource (opportunity) cost*** was only calculated for four water regions where the demand-supply water balance is negative, *i.e.* in Aegean Islands, East Sterea Ellada, East Peloponnesos and Thessaly. The resource cost was approximated considering the best water source alternative in each area (the cost of water desalination, the cost of recycled water, etc.)
- The ***environmental cost*** was obtained using a "Benefits Transfer" of values obtained in a large number of valuation studies which applied stated preferences methods. This technique allows for adjusting the values obtained in these studies using relevant socio-economic data for the areas where the studies were performed and the areas where the values are to be "transferred".

The level of cost recovery has been calculated as the percentage of the total cost of water services that are recovered by the collected revenues from water services. The revenue figures used by the Greek Government include both tariffs set by water companies to water users and water polluters. Furthermore, Common Agricultural Policy subsides attributable to irrigated agriculture are included as a cost in the calculation of cost recovery for agricultural water users. The average cost recovery level in Greece is nearly 65% for domestic and industrial uses and 54% for agricultural users. Total cost recovery level is also 64% for all uses. With a couple of notable exceptions, water companies do not cover their costs. Furthermore, not even financial costs are covered with the collected revenues. Average water tariffs have been calculated by dividing the total amount of revenues paid by farmers and the amount of water used in each water region. These range from an average EUR 0.011/m^3 in Central Macedonia to EUR 0.1/m^3 in Crete.

Table 3.6. Water demand and cost of water services in Greece, 2007

	Water demand (Hm^3/year)		**Financial cost** ('000 EUR/year)		**Resource (opportunity) cost** ('000 EUR/ year)	**Environmental cost** ('000 EUR/year)		**Total costs** ('000 EUR/year)	
Water district	Irrigation	All uses	Irrigation	All uses	Irrigation	Irrigation	All uses	Irrigation	All uses
TOTAL	6 827	7 907	118 950	3 408 488	140 166	47 502	62 165	306 618	3 610 819

Table 3.7. Full cost recovery for water services in Greece, 2007

	Revenue collected from water tariffs ('000 EUR/year)		**Average water tariff** (EUR/m^3)		**Total cost recovery** (%)	
Water district	Irrigation	All uses	Irrigation	All uses	Irrigation	All uses
TOTAL	165 608	2 301 955	0.0243	0.2911	54	64

Source: Adapted from Garrido and Calatrava (2010).

3.4.4. Financing water infrastructure related to agriculture

Many irrigation areas in OECD countries face the problems of ageing infrastructure and a limited revenue base from which to fund maintenance and repair activities. The drive toward cost recovery for storage and delivery services arising from water reform policies described above, means that both water suppliers and irrigators are beginning to consider the strategic evaluation of infrastructure renewal to remain viable. Losses typically arise from poorly maintained water delivery systems and on-farm pipelines, as well as losses from inefficient water application technologies (some of these losses leach back into the environment, although may involve transporting pollutants, such as salts, into water bodies).

In **Japan** and **Korea**, for example, there is a pressing need to upgrade and repair the massive stock of ageing irrigation facilities accumulated in earlier decades (Nickum and Ogara, 2010). **Japan's** Stock Management Programme is aimed at this problem, while in **Korea,** such upgrading may involve renovation for multipurpose uses. For **Hungary,** most of the public water facilities, (serving drainage and irrigation purposes) amounting to about 37 000 km and 312 public-purpose pump stations, are in poor condition and require reconstruction (Hungarian government's response to the OECD questionnaire at www.oecd.org/water). The **United States** has also been concerned with addressing the maintenance of its public irrigation infrastructure, in common with many other OECD countries, as discussed in Box 3.13.

Answers to many irrigation infrastructure maintenance questions turn on which parts of the water control system can be maintained and on the consequences of a loss of function due to poor maintenance of any part. Canals and structures in irrigation canals should have sufficient capacities, and should be able to assure required water levels. Drainage systems should also have sufficient capacities to secure a desired level for water distribution. Proper maintenance requires information on the characteristics of the system and its elements and an understanding of which functions each contributes. Such an information database is necessary for an adequate monitoring, planning, execution and control of maintenance, for cost effectiveness of the work and for its cost recovery.

In general, however, information on the current levels and future needs for financing water management and infrastructure related to agriculture is poor across OECD countries. The total costs for maintaining and modernising the existing water delivery systems to farms is likely to be substantial. This is because of the need to address leakages and losses from water delivery systems on and off-farm, and also that in most cases no contingency has been made for capital investment for system renewal given that typically publicly owned irrigation systems have only charged farmers for O&M costs and not capital renewal costs. In addition, there are the financial costs for controlling non-point pollution from agriculture, and flood control costs, such as on-farm drainage.

With the increasing transfer of water infrastructure operation and maintenance from government agencies to farmer or water user associations this raises questions as to future sources of finance and asset management. The transfer of financial control and investment management requires water user groups to seek private-public partnerships to raise capital and develop skills in long term asset management for renewal of irrigation infrastructure. In addition, given the environmental considerations in large scale irrigation schemes there has been reluctance of financial institutions to engage in these projects irrespective of their overall benefits.

Box 3.12. Irrigating with groundwater from the Ogallala Aquifer in the United States

The Ogallala Aquifer lies beneath portions of eight states in the American west, including Texas, New Mexico, Kansas, Oklahoma, Colorado, Nebraska, Wyoming and South Dakota. The Ogallala has been the source of substantial, large-scale irrigation development, beginning in the 1950s, when affordable technology became available for extracting groundwater and applying it to large fields of cotton, corn, winter wheat, and sorghum. The number of wells on the Texas High Plains rose from 48 000 in 1958 to 101 000 in 2000, as farmers increased their production of irrigated crops. The Ogallala is largely a fossil aquifer with a very slow rate of natural recharge. By 1977, groundwater levels were declining by at least 15 cm per year in 82% of the area irrigated with groundwater in Texas. Severe overdraft was observed also in Kansas, Oklahoma, and New Mexico. The cumulative decline in groundwater levels has exceeded 30 metres in some areas of Texas and Oklahoma.

The economy of the region depends largely on crop and livestock production and processing, yet the rate of withdrawal from the Ogallala greatly exceeds the rate of recharge. The unsustainable use of water from the Ogallala has attracted substantial attention from state and federal agencies in recent years. Most states have passed laws that enable the formation of groundwater management districts, controlled by local irrigators, to implement programs for optimising the long-term use of water from the aquifer. In Kansas, New Mexico, and Colorado, farmers must apply for permits from groundwater management districts to drill new wells. Permits are not issued if new wells will impact water availability for nearby farmers. Farmers in Kansas are required also to measure the volume of groundwater they use each year and to provide that information to the local management district.

Farmers on the High Plains region of Texas can withdraw and utilise groundwater without regulation, as the Texas Supreme Court has ruled that a landowner is the absolute owner of the soil and percolating water. Irrigation expanded rapidly in the region during the 1960s and the early 1970s, before entering a period of decline, driven largely by the increases in energy costs and the diminishing productivity of irrigation wells. Irrigated area reached a low point of 1.59 million ha in 1989, before recovering to 1.87 million ha in 2000, about the same area that was irrigated in 1958. As the irrigated area has changed over time, so too have farm-level choices regarding irrigation technology. Gravity-flow surface irrigation methods have largely been replaced by centre-pivot and low-pressure sprinkler systems and subsurface drip irrigation.

Lacking administrative authority to limit pumping in Texas, several agencies have worked with irrigators to encourage improvements in water management that will reduce the aggregate rate of groundwater withdrawals. Declining groundwater levels and rising prices of natural gas also have motivated farmers to improve irrigation management. The estimated cost of pumping water from the Ogallala increased from USD 0.08 per mm to more than USD 0.20 mm in some areas. The current estimated investment cost for an irrigation system in the region is USD 741 per hectare and the estimated variable cost of pumping water (from a depth of 61 metres) and operating the system is USD 772 per hectare. In a sense, the increasing costs of two scarce resources (water and natural gas) are motivating necessary adjustments in water use, with research indicating that in any given year, higher natural gas prices can cause up to an 18% reduction in the volume of water pumped for irrigation in the region.

The costs of pumping groundwater will continue to increase with rising energy costs and with declining water levels. State governments will likely increase their efforts to manage groundwater as scarcity increases in many areas, and as the public becomes more concerned about the regional economic implications of groundwater overdraft. Recent increases in public awareness of the potential implications of climate change and public concerns regarding sustainability are likely to encourage public officials to intensify their management of groundwater resources, while also enhancing the likelihood that farmers will accept new regulatory measures that might include charges that reflect scarcity values.

Source: OECD Secretariat, adapted from Wichelns (2010b).

Box 3.13. Financing irrigation infrastructure in the United States

The experience of the United States Bureau of Reclamation (Reclamation) provides an illustrative example among OECD countries of the issues and challenges for policy makers in addressing irrigation infrastructure maintenance. The Reclamation Act of 1902, which created the Reclamation, set in motion a major programme to provide federal financing, construction, and operation of water storage and distribution projects to reclaim arid lands in the western states. Most large dams and water diversion structures in the west were built by, or with the assistance of, the Reclamation (the U.S. Army Corps of Engineers [Corps] also operates and maintains a considerable inventory of dams and other water control infrastructure throughout the US, with the Corps indicating in financial year 2006 it had USD1.8 billion in deferred maintenance for its civil works activities)

The Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner. In most cases this has meant developing water supplies primarily for irrigation to reclaim arid lands in the West. As of 2008, the Reclamation operates and maintains 2 122 water and power structures in the 17 western states. Among these facilities are 471 dams, 348 reservoirs, 58 power plants, and numerous water delivery facilities. This infrastructure provides water to 31 million people and provides irrigation water for 10 million acres of farmland that produce 60% of the nation's vegetables and 25% of its fruits and nuts. With US population and accompanying development continuing to move into the west, the need for secure infrastructure to deliver greater quantities of water in future will be important.

Almost from the beginning, the U.S. federal government has wrestled with the problem of repairing the Reclamation's infrastructure. Early in the reclamation programme, the US Congress decided to require water users to pay for a part of the repair and maintenance of the facilities. The Reclamation reported recently that its current infrastructure systems are in generally good condition, but acknowledged that the long term trend will show some decrease in reliability of the facilities under its control in 2009. The Reclamation recognises that it faces approximately USD 3 billion worth of rehabilitation needs for its ageing infrastructure over the next 20 years.

Based on the agency's internal facility reliability rating system, which measures the percentage of water facilities in good or fair condition, it determined that in the financial year (FY) 2007 that 99% of all facilities met those criteria. The agency stated that the reliability index may fall below 90% in FY 2009 and following years. Much of the Reclamation's current infrastructure is now 50 years old or older, and its proper operation and maintenance are a top priority. The administration has proposed USD 396 million in budget authority for FY 2009 to ensure that its facilities are operated and maintained safely and reliably, a slight increase over the USD 388 million enacted for operation and maintenance expenditure in FY 2008.

At the inception of the Reclamation Program the philosophy was that all reclamation project costs should be repaid in full except interest on construction costs. However early reclamation cost sharing policy resulted in repayments to the government falling short of planned levels. This led to a series of changes in the repayment provisions culminating with the Reclamation Act of 1939, which completely revised reclamation policy from total repayment of cost to repayment on an ability to pay basis as determined by Reclamation. Charges for Reclamation supplied irrigation water were no longer required to reflect the cost of water supply. The Reclamation Reform Act of 1982 required that new contracts charge full supply costs of operation and maintenance (including repayment of previously underpaid operation and maintenance). Even so, concerns have persisted about the degree to which reclamation irrigation projects are subsidised and the potentially inefficient economic use of public resources. However, since the 1982 Reclamation Act, the 1986 statutory requirement, and the 1992 Central Valley Project Improvement Act have generated notable increases in irrigation prices in California's Central Valley (Wichelns, 2010b).

Source: Adapted from Ward (2010) and Wichelns (2010b).

The key factors that might be able to promote increased levels of investment in irrigated agriculture include:

- Defining clearer titles to water rights that promote market transfers of water;
- Increasing competition for water, and a reallocation of agricultural water supplies to meet emerging uses;
- Developing regulatory measures that require the upkeep and maintenance on infrastructure, as well as minimum flows for environmental needs; and,
- Increasing the cost recovery rates of water supplied to farmers so there is a flow of financial resources to support water delivery infrastructure maintenance and renewal.

3.5. Climate change and flood and drought risk management[3]

3.5.1. Overview

Nearly all OECD countries are actively engaged in government led research concerning the future impacts of climate change on agricultural water management. The emphasis of research varies across countries, however, reflecting the varying anticipated impacts of climate change on agriculture and water resources across OECD countries (see the OECD questionnaire at www.oecd.org/water).

The main focus of climate change research for almost all countries involves analysing the implications for agricultural production, assessing regional impacts of expected changes in precipitation and water availability, and examining the efficiency (mitigation and adaptation) of different farm practices and systems under a range of climate change scenarios. Where issues of water scarcity are already exerting pressure on agricultural production (*e.g.* regions of **Australia, Spain** and the **United States**) climate change research is directed, in particular, at evaluating soil conditions and land use suitability, improving water use efficiency, and developing drought resistant new crop varieties (see the OECD questionnaire at www.oecd.org/water).

The climate change research undertaken by most countries is already being factored into water resource management policy considerations related to agriculture in a growing number of countries (see the OECD questionnaire at www.oecd.org/water). The emphasis in most countries continues to be on researching climate change impacts on agriculture and water resources and raising policy decision makers and the public's awareness to the issues and challenges. Nearly a quarter of the OECD membership, however, report that climate change has a medium to a very extensive ranking in terms of the extent to which climate change is currently being taken into account in policy decision making in relation to agricultural water resource management (see the OECD questionnaire at www.oecd.org/water).

Illustrative of the growing priority of climate change in policy decision making in agricultural water resource management includes (see the OECD questionnaire at www.oecd.org/water): the 2008 **Australian** national plan *Water for the Future*, one of four key priorities for the Federal government (Box 3.8); recognition in the **French** Water Act (2006) of the need to adapt water management policies to the impact of climate change; inclusion of climate change in the **Spanish** Hydrological National and Basin Plans (Box 3.17); the **United Kingdom's** Environment Agency new climate change policy strategy is taking account of the expected increase in irrigation demand; the

United States is developing long term strategies to update institutions and agricultural policies to adapt to climate change; and in **New Zealand** water policy and climate change policy are becoming more inextricably linked (Box 3.14).

As the frequency and severity of drought and flood events is increasing this is leading to rising budgetary costs for governments to support farmers and the rural community, and higher costs for private insurers (OECD, 2006). Efforts to address flood and drought events in agriculture and society as a whole, is being frustrated by the fragmentation of responsibility and the lack of policy coherence in agricultural, environmental, land and water policies to address these problems.

Where farmers are guaranteed government support in times of flood and drought disasters, this is not providing the necessary incentives to improve farmer self-reliance and risk management for adverse events. Hence, greater policy attention and investment will be required in drainage and water control (for floods), water retention (droughts) and farming systems and practices that can reduce economic losses to farmers and water flows across farmland (Rosenzweig *et al.,* 2004).

3.5.2. Flood policies and agriculture

Flooding remains the most significant natural hazard worldwide. In the period 1985-2008 extreme rainfall events may have been responsible for over USD 320 billion of damages and over 10 000 deaths in OECD countries (Morris *et al.,* 2010). Although the largest share of economic flooding costs is borne by urban communities, agriculture occupies a large proportion of the landscape and has an important role to play in both flood mitigation and adaptation.

There is clear evidence from many OECD countries that the incidence and severity of flooding events have been increasing over recent decades, with the resulting damaging impacts on agricultural production and infrastructure (*e.g.* buildings, fencing, etc.). Human alterations of the hydrological characteristics of watersheds has increased runoff and narrowed channels. Land-use policies have also encouraged urbanisation in areas at risk to flooding events, and thus increased the economic cost associated with a given flood event. The expectation is that such events will occur more frequently in the future due to climate change and changes in catchment land use (see the OECD questionnaire at www.oecd.org/water).

Flooding can be viewed as an environmental risk. Hence, a flood event has a *source,* such as an extreme rainfall event, with potential to cause flooding conveyed through a *pathway,* the land surface and hydrological system, to a *receptor* where flooding occurs (Figure 3.4). The risk of flooding to people and communities depends on the likelihood of a flood occurring (probability) and the consequences of the event when it does occur. The risk may be reduced by a combination of mitigation and adaptation. *Mitigation* refers to actions that impact the source or pathway to reduce the probability of a flood occurring. *Adaptation* refers to actions taken to reduce the impact of flooding in receptor areas.

Box 3.14. Developing policy linkages between agriculture, water and climate change in New Zealand

The linkages between water policy and climate change policy are becoming inextricably linked. It is becoming more prominent in the work on climate change adaptation. Within the Sustainable Land Management and Climate Change Programme, significant work under one pillar of the programme, is looking at the issue of adaptation to climate change.

Adapting to climate change

Climate change is likely to have a mixed impact on New Zealand land management. Over the next 100 years, the country is expected to experience warmer temperatures and changes in the amount and distribution of rainfall. This will result in improved growing conditions and longer seasons in some regions. It is also likely to lead to an increase in the frequency and severity of both extreme storm events (in some areas) and drought in others (especially in the east). Increased biosecurity risks from pests and diseases will also need to be managed. Agricultural productivity is expected to be affected, for better and worse, by these projected changes.

The Government will work with the agriculture and forestry sectors, local government and Māori to identify activities to be included in a proposed new five-year Adaptation Programme for the sectors. This programme will help the sectors build up the necessary skills and infrastructure needed to respond to the risks posed by the changing climate, as well as take advantage of the new opportunities. The Government has agreed to fund this work to a total of more than NZD 7 million over the five years 2008-12 and a further NZD 910 000 per annum thereafter. This will be supported by further investment in research and innovation and technology transfer. The Adaptation Programme will be linked to work already being carried out by the sectors, to local authority regional, district and community plans, and to broader central government sustainability initiatives, among which of particular relevance to agriculture, include the Community Irrigation Fund and Flood Risk Management Review, described below.

Community Irrigation Fund

The Community Irrigation Fund (CIF) was established in 2007 and is a contestable fund of NZD 6.4 million spread over an 8-year period. It is part of the government's wider sustainability and climate change initiatives and funds up to half of the cash costs of appropriate activities. The CIF aims to build resilience in agricultural producers and rural communities, and ensure their long-term economic growth within sustainable environmental limits by reducing the risks they face from water shortages caused by climate change.

The CIF helps agricultural producers and rural communities adapt to climate change by assisting promoters of community water storage and/or irrigation schemes overcome the high transaction costs of generating investor and/or community support. A community scheme is one that is initiated, developed and used by multiple members of a rural community, primarily for irrigation.

Flood risk management review

The Ministry for the Environment led a two-year review of how New Zealand manages its flood risk and river control. This was completed in June 2007. The Ministry worked closely with local government and other government agencies on the review, including the Ministry of Civil Defence and Emergency Management, Ministry of Agriculture and Forestry, Department of Internal Affairs and the Department of the Prime Minister and Cabinet.

The review found that central government needs to strengthen the current policy framework and provide better guidance on flood risk assessment and good practice. The challenge New Zealand now faces is how best to reduce the damages and losses from flooding as part of our everyday living and working lives. Over 100 New Zealand cities and towns, along with some of our most productive farmland, are located on floodplains. The review looked at what was being done to manage flood risk and where there were any problems.

New Zealand suffered major flooding in 2004, affecting the lower North Island and the Bay of Plenty. The floods led to major regional social, economic and environmental disruption, requiring substantial relief from central government. Following these events the flood risk management review and work programme was agreed, and a steering group was established. Over the years ways to manage this flood risk have been developed. After the large floods in 2004 the Government decided to review flood risk management to ensure the current framework is robust. The Ministry for the Environment led the review, and a Steering Group provided direction and guidance throughout the review. The review covered three key topics:

- The role(s) of central government, local government and communities in ensuring good risk management practices are adopted in managing rivers and floods.
- Funding and affordability, essentially asking who benefits, who pays, and who can afford flood risk mitigation.
- Current flood risk management practices and whether these practices are appropriate, now and into the future, to meet the needs of New Zealanders.

Briefly, the review found that the current flood risk framework is not fundamentally flawed but that important issues need to be addressed. The current practices of central and local government need to improve to manage current flood risk and adapt to future climate change. Funding and affordability are very real concerns for smaller, less wealthy communities. The roles of communities, central and local government are broadly right, although central government could be more active in reducing flood risk.

Flood risk will increase with climate change. Central government currently spends most of its investment in flood risk management on the response and recovery phases. Investment in the reduction phase – to provide information, guidance and assistance, as well as resources – would help local government to more effectively manage flood risk and prepare for climate change. One of the main outcomes of the review is the development of a National Policy Statement on Flood Risk Management, which will be developed under the Resource Management Act 1991.

Source : New Zealand government's response to the OECD questionnaire at www.oecd.org/water.

Figure 3.4. Sources – Pathways – Receptors model applied to flood risk

Sources →	**Pathways** →	**Receptors**
Weather-related phenomena which generate water that could cause flooding – heavy rain, snowmelt, extreme tide, defence breach.	Mechanisms by which water travels from its source to places where it may affect receptors – overland flow, streams, rivers, flood plains.	Physical entities that are potentially vulnerable to flooding – people, property, infrastructure, habitats.

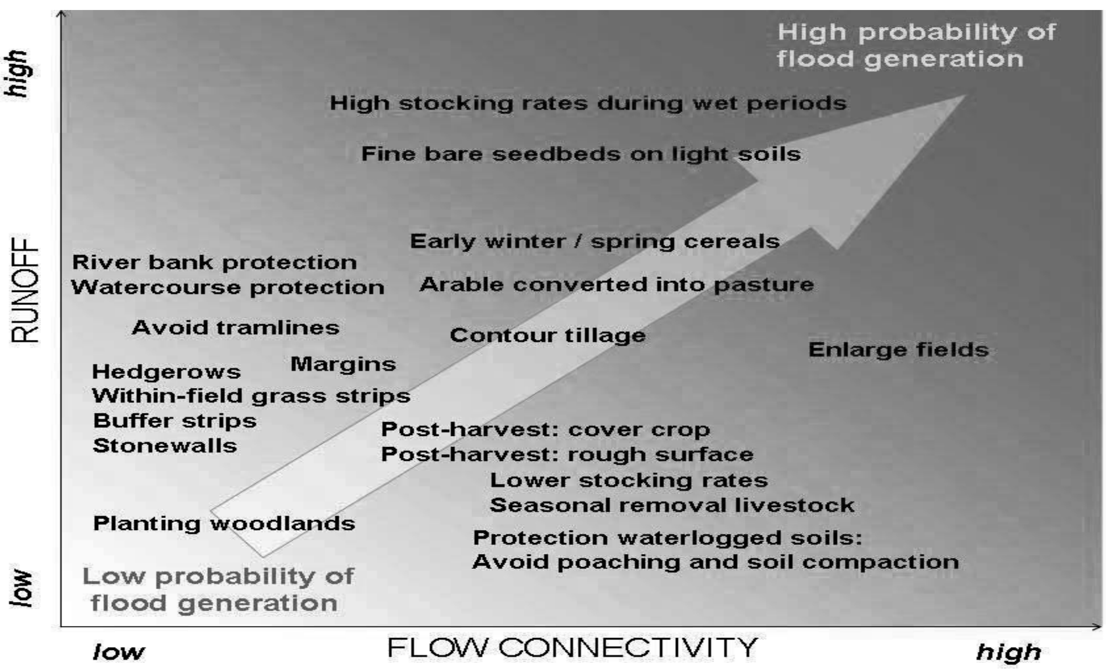
Source: Morris *et al.* (2010).

Agricultural land can act as a "pathway" for the generation of floods which can result in damage. There is a general perception that the intensification of agriculture over the past 50 years in many OECD countries has resulted in greater and more rapid floods following extreme rainfall (Morris *et al.,* 2010). Some changes in land management practices, for example, have reduced the infiltration capacity of the soil, for example, drainage systems have been "improved" to evacuate water from agricultural land more quickly. But practices that encourage retention of water in the landscape can contribute to flood risk mitigation, especially for smaller, more frequent events. Practices such as (*inter alia*), low stocking rates, grazing management, low ground pressure tyres, and soil improvement measures encourage infiltration and reduce surface runoff, whereas measures such as contour ploughing and retention ponds slow down the rate of runoff from the land (Figure 3.5).

The linkages between flooding and land management practices in agriculture also need to be viewed within the context of regional land use planning and broader, economy-wide mitigation strategies to address flood risks. Increased impervious surfaces with urban expansion results in reduced groundwater retention that supply base flows during drought and increased intensity of flows during flood events. Conversion of farmland to non-agricultural uses in floodplain areas increases the potential cost of flood damages while reducing the potential use of these lands as a flood sink. This highlights the point that planning for sustainable water resource management in agriculture should not be independent of regional land use planning.

Agricultural land is often the receptor of flooding. The impact of flooding on agriculture varies considerably according to tolerance of the particular crop or land use activity to excess water, and the frequency, duration, depth and seasonality of the event. Where flooding is frequent, the use of the land may be limited to low productivity, flood resilient enterprises. Less frequent flooding may cause damage and losses to higher value land uses. If the likelihood of flooding is going to increase in the future, farmers will need to adapt by moving to more flood resistant or resilient enterprises and adopting measures to facilitate recovery after a flood event. These adaptations may also provide opportunities for parallel enhancements, such as biodiversity improvement through wetland re-creation and enhanced public access.

Figure 3.5. Impacts of selected land management practices on flood generation



Source: Morris *et al.* (2010).

National policies for agricultural flood risk management in OECD countries have included a combination of mitigation and adaptation (Figure 3.6 and the OECD questionnaire at www.oecd.org/water). Mitigation has mainly taken the form of public investments in flood defence and land drainage to support agricultural production. There have been few policies that directly mitigate flood generation from farm land, despite concerns that rural land use can contribute to flooding. Some features of agri-environmental schemes now include components which are likely to reduce runoff, which contributes towards lower rates of soil erosion and diffuse water pollution. However, many policies that seek to influence agricultural land management in order to control diffuse pollution and soil erosion are also thought to have a beneficial impact on flood risk management. These policies typically adopt a non-regulatory approach, with emphasis on a mix of voluntary measures (such as agri-environmental schemes), supported by economic incentives to farmers, with advice on improved environmental practices.

Adaptation interventions that reduce vulnerability to flooding, mainly involve in OECD countries providing flood warning systems, guidance on building flood resilience, and emergency relief and compensation (Figure 3.6 and the OECD questionnaire at www.oecd.org/water). Policies also include adaptation measures which seek to exploit potential synergy in the landscape. Examples include flood management and agri-environment initiatives that combine flood risk management, biodiversity and agricultural livelihoods in floodplains. The creation of washlands and wetlands are examples of this.

National initiatives, such as “Making Space for Water” (**England** and **Wales**), “Space for Rivers” (the **Netherlands**), or **Hungary’s** *Improvement of the Vásárhelyi Plan* (Box 3.15), have encouraged a re-appraisal of land management options for floodplain areas. Agricultural land in washlands, polders and flood retention basins may be used for floodwater storage (reservoirs) to mitigate flood risk elsewhere in the catchment. They provide opportunities to deliver multiple benefits, such as floodwater storage and enhancement of biodiversity, and potentially provide alternative sources of income to land managers.

New Zealand has also undertaken a review of its flood risk management policy framework, with emphasis on the need for local and national governments to adapt current practices to prepare for climate change (Box 3.14). The approach of New Zealand to flood management risk, related to agriculture, involves a mixture of regulations, voluntary and other measures, but not economic incentives.

3.5.3. Drought policies and agriculture

As in the case of floods, the evidence is clear that in many OECD countries the incidence and severity of drought events have been increasing over recent decades, with the resulting damaging impacts on agricultural production, as has been the case for floods. The expectation is that such events will occur more frequently in the future due to climate change (Figure 1.2 and the OECD questionnaire at www.oecd.org/water).

National policies that directly address agricultural drought risk management in OECD countries are not widespread, but where they have been adopted include a combination of mitigation and adaptation measures (Figure 3.7 and the OECD questionnaire at www.oecd.org/water). Typically, most countries mitigation measures have taken the form of increasing water retention and storage both on-farm and off-farm (i.e. in terms of improving irrigation infrastructure).

Figure 3.6. Policies regarding flood risk management and agriculture in OECD countries

Policies	Instruments	Countries
	MITIGATION	
	Regulatory instruments	
Planning	Restrictions in high risk zones	Austria, Finland, France, Ireland, Poland, Portugal, Spain
	Consideration of changes in land use management on runoff	Belgium, the Netherlands, Portugal
	Economic incentive measures	
Water retention and storage	Upland runoff retention	Belgium, Finland, France, Poland, Spain
	Lowland water storage: polders, washlands	Austria, Belgium, Czech Republic, France, Hungary, the Netherlands, United Kingdom, United States
	Best management practices (*e.g.* agri-environment schemes)	Czech Republic, France, Greece, Hungary, the Netherlands, Portugal, United Kingdom
	Wetlands	Belgium, Finland, France, Hungary, Poland, Sweden, United States
	Erosion control	Belgium, Czech Republic, France, United States
	Afforestation	Poland, Portugal
	Other policy instruments	
Flood defence agricultural areas	Increase flood defence	Belgium, Czech Republic, Greece, Hungary, Poland, Spain
	Withdrawal of flood defence	Austria, Finland, Ireland, United Kingdom
	Land drainage	Poland, Portugal, Sweden
	River restoration	Austria, Canada, France, the Netherlands, Switzerland, United Kingdom
Land use	Lowland water storage: paddy fields	Japan, Korea
	ADAPTATION	
	Economic instruments	
Compensation mechanisms flood damage	Disaster relief agriculture	Australia, Austria, Belgium, Czech Republic, Finland, France, Greece, Hungary, Italy, Japan, Korea, the Netherlands, Poland, Portugal, United States
	Subsidised crop insurance	Canada, France, Japan, Korea, Poland, Portugal, Spain, United States
	Interest subsidies for loans	Belgium, Poland, Portugal
	Compensation for water retention	Austria, Belgium, Hungary, the Netherlands
	Other policy instruments	
Information	Flood risk maps	Austria, Belgium, Japan, Spain
	Warning system	Belgium, Spain, United Kingdom

Source: Adapted from Morris *et al.* (2010), and drawing on the OECD questionnaire at www.oecd.org/water.

Box 3.15. Flood risk management and agriculture in Hungary

Between 1994 and 2004, floods occurred annually except in 1997, 2003, and 2004. The two major rivers, the Danube and the Tisza, overflow their banks every 2-3 and every 1.5-2 years, respectively. Nearly one-half (44%) of the length of principal levees (4 180 km) does not meet regulatory standards for levee height. Former flood plains accommodate one third of all arable land, as well as 32% of railroads, 15% of roads, and over 700 settlements with 2.5 million inhabitants. Four extraordinary flood events have happened in the Tisza River Basin area between 1998-2001, causing considerable damage.

The evaluation of the serial floods made it clear that the approach to flood prevention by heightening and strengthening dykes should be reconsidered. As a result the Hungarian Government launched a programme in 2003, the so called Improvement of the Vásárhelyi Plan (IVP), which aims to increase the discharge capacity of the flood bed together with ecological revitalisation of the floodplain area through reservoirs that can receive flood water. The IVP in addition to its main objective to increase flood safety along the Tisza River, also aims to develop landscape management in the area of the reservoirs, as well as encourage regional, rural and infrastructure development, which may result in social and environmental benefits in the Tisza River Basin.

The reservoirs have been established on low-value, privately owned farmland. In the frame of the IVP the government provides support for establishment of wetland ecofarming, and extensive pasturage in the area of the flood bed and reservoirs, as well as providing other agri-environmental support. Most of the territory of the Tisza-Valley is canalised for conveying water and supplying other rivers (Körös and Szamos). On these rivers there are also reservoirs for flood management and supplying water for irrigation. Payments are also available to the owners whose territories are located on the reservoirs used for flood protection purposes, with farmers eligible for agri-environmental support.

Source: Hungarian government's response to the OECD questionnaire at www.oecd.org/water.

Mitigation measures have also encouraged the adoption of agri-environmental practices that increase soil moisture retention, such as changing cropping systems toward drought resistant crops and the uptake of conservation tillage, as well as providing farm advice and technical guidance to mitigate drought risks. The development of processes for monitoring and evaluating drought situations, supported by research and experimental development, together with technological changes in using water and adapting crops, will play a role in the context of climate change. There have been few policies that directly seek to adapt agriculture to drought risks, leaving aside the widespread use of disaster relief payments and loans.

With growing concerns for the expected increase in drought events under climate change, a number of countries have initiated recent reviews of their existing drought policies. **Canada, Hungary, Turkey** and the **United Kingdom**, for example, are all in the process of examining their national drought policies as they affect agriculture. **Australia** is also undertaking a review of national drought policies, against a backdrop of the worst period of drought impacting agriculture on record (Box 3.16). While in **Spain** several measures have been adopted in response to climate change, as precipitation and runoff patterns have been on a declining trend during the last 20 years compared to the long-term average, especially in dry regions (Box 3.17).

Figure 3.7. Policies regarding drought risk management and agriculture in OECD countries

Policies	Instruments	Countries
	MITIGATION	
	Regulatory instruments	
Planning, including economy wide level flood protection programmes	National Drought Strategy or Water Efficiency Programme	Australia (under review), Canada (under review), Portugal, United Kingdom
	Water user association and Farm water plan	Netherlands, Turkey
Minimum environmental flows (rivers) and stocks (lakes)	Benchmarking in water channels	Australia, Austria, Denmark, Finland, France, Germany, Greece, Italy, Japan, Korea, New Zealand (proposed), Poland, Portugal, Spain, Switzerland, UK, US
Irrigation restrictions	Bans on irrigation in times of drought	UK
	Economic incentive measures	
Water retention and storage	Off-farm irrigation infrastructure	Australia, France, Greece, Hungary, Italy, Korea, Poland, Portugal, Slovak Republic, Spain, Turkey, United States
	Upgrades of on-farm irrigation/ water storage	Australia, Canada, Greece, Italy, Poland, Portugal, Switzerland, Turkey
	Rainwater storage/capture	Belgium, Ireland, Poland, United Kingdom
	Water recycling in fields or paddy rice fields	Japan, Korea
	Desalinisation	Spain
	Recycled treated sewage	Spain
Soil Moisture retention	Agri-environmental practices (*e.g.* conservation tillage, restoration of terraces, change cropping system)	Canada, Czech Republic, France, Greece, Hungary, Poland, United States
	Wetlands restoration and conservation	All OECD countries, except Turkey,
	Other policy instruments	
Farm advisory, farmer technical guidance and education	Farmer advice, technical guidance and educational programmes	Australia, Austria, Canada, Hungary, New Zealand, Portugal, United States
Information	Research	Australia, Austria, Belgium
	Water scarcity indicators	Spain
	ADAPTATION	
	Economic instruments	
Compensation for drought losses	Disaster relief payments and loans	All OECD countries
	Other policy instruments	
Information	Risk management advice	Australia
	Research	Australia, Belgium

Source: OECD Secretariat, drawing on the OECD questionnaire at www.oecd.org/water.

Box 3.16. Australia's comprehensive review of national drought policy

The Australian Government is conducting a comprehensive national review of drought policy. The review includes three separate assessments: the first examines the implications of future climate change for the current Exceptional Circumstances (EC) standard of a one in 20-25 years event, while the other two cover reviews of economic and social aspects.

The Australian Bureau of Meteorology and CSIRO (2008) analysis of the extent and frequency of exceptionally hot years have been increasing rapidly over recent decades and that trend is expected to continue. Further, over the past 40 years (1968-2007), exceptionally hot years are typically occurring over 10-12% of the area in each region, i.e about twice the expected long-term average of 5%. By 2010-40, the mean area is likely to increase to 60-80%, with a low scenario of 40-60% and a high scenario of 80-95%. On average, exceptionally high temperatures are likely to occur every one to two years.

The current Exceptional Circumstance trigger, based on historical records, has already resulted in many areas of Australia being drought declared in more than 5% of years, and the frequency and severity are likely to increase. The principal implication of the CSIRO study is that the existing trigger is not appropriate under a changing climate.

Farmers and their suppliers need user-friendly, reliable and up-to-date location-specific information on historical climatic conditions and future climate variability. Key here is the risk of drought on timescales from seasons to decades. The CSIRO report identifies a number of activities and areas of research for improving information, including:

- Further improvement of drought monitoring capability and maintenance of networks for rainfall and other key climate observations.
- An online climate information system which readily integrates climate change projections with the historical database.
- Participatory studies to more accurately identify the climate change information needs of the different rural sectors.
- Research to improve climate change projections and seasonal-to-interannual forecasts, particularly with respect to specific rural sectors and a localised scale.
- More detailed analyses of projected changes in exceptional climatic events in smaller regions and beyond the next 20-30 years.

In a parallel review of Government Drought Support by the Productivity Commission (2008) some of the key conclusions to emerge to date from this review are that:

- Many Australian farmers and rural communities are experiencing hardship as a result of a severe and prolonged drought. While this is not new to dryland farming, the ‘irrigation drought’ is uncharted territory.
- Australia has always had a variable climate, with drought being a recurring feature. Looking to the future, most agricultural regions need to prepare for higher temperatures and for some, more frequent periods of exceptionally low rainfall.
- Most farmers are sufficiently self-reliant to manage climate variability. In 2007-08, 20% of Australia’s 150 000 farms received drought assistance, totalling over AUD 1 billion, with some on income support continuously since 2002. Even in drought declared areas, most farmers manage without assistance. For instance, from 2002-03 to 2006-07, on average, more than 70% of dairy and broadacre farms in drought areas received no drought assistance.

- All governments agree that the current approaches to drought and *Exceptional Circumstance* declarations are no longer the most appropriate in the context of a changing climate. In marked contrast to the policy objectives, current drought assistance programs are not focussed on helping farmers improve self-reliance, preparedness and climate change management.
- The National Drought Policy should be replaced with expanded objectives for *Australia's Farming Future*. These would recognise that the primary responsibility for managing risks, including from climate variability and change, rests with farmers — underpinned by more appropriate forms of government support.
- Research, development, extension, professional advice and training to improve business management skills can help build farmers' self-reliance and preparedness. These areas warrant significant government funding provided they are well targeted, area appropriate and deliver a demonstrable community benefit.
- Policies relating to water, natural resource management and climate change all impact on farm businesses and local communities and need to be better integrated.

Sources: OECD Secretariat, adapted from the Australian Bureau of Meteorology and CSIRO (2008); Productivity Commission (2008).

Box 3.17. Spanish measures to prepare irrigated agriculture for climate change impacts

In Spain, the precipitation and runoff patterns show a clear decrease during the last 20 years compared to the long-term average, especially in dry regions. Several measures have been adopted as a response to potential climate change.

The river basin Plans currently under preparation, which are the basis for the assignment of water rights to different users, use the short hydrological series which goes from 1980/81 to 2005/6. In addition, the basin Plans include a specific analysis of the potential effect of climate change, taking into consideration a potential decrease in runoff of up to 11%, depending on the basin.

During the period 2006-08 an investment of EUR 2 billion has been made to improve irrigation systems and enhance water savings, covering an area of 876 000 ha. The modernisation schemes include:

- Transforming gravity irrigation systems into pressure systems, allowing an increase of global irrigation efficiency;
- Enabling irrigation system operators to measure volumes and apply volume-based tariffs; and,
- Improving the irrigation system infrastructure (although at present, around 60% of the total irrigated area is equipped with pressure systems).

Drought Management Plans have been prepared for different river basins, including defining an indicator system, and determining objective thresholds and specific measures to be gradually implemented. The indicator and threshold system establishes the starting and ending for a drought, and the severity levels, as well as thresholds of pre-alert and alert to re-assign water resources in situations of shortage and prevent the deterioration of water status. Once the drought event has finished, all practicable measures are taken to restore the water bodies to their previous status. An evaluation of the effectiveness and efficiency of the threshold system and the measures taken is to be undertaken, in order to subsequently revise and update the existing Drought Management Plans.

Source: Personal communication with the Spanish authorities.

3.6. Knowledge and assessment of water resource management in agriculture

The knowledge and monitoring of hydrological, agricultural and environmental linkages is less well developed than have been the advances in water policies. The continuation of this disconnect runs the risk that decision makers are poorly informed and that policies are inadequately implemented and evaluated. These gaps in knowledge, science and monitoring are compounded as agriculture and water resources enter an era of uncertainty, greater variability and higher risks as a result of climate change.

A substantial effort is now underway across most OECD countries to address information deficiencies to better guide policy-making (see the OECD questionnaire at www.oecd.org/water). Encouraging examples are the monitoring of minimum water flow rates in rivers as part of environmental planning in many countries. Moreover, comprehensive river basin assessments are being undertaken, for example, in the EU under the Water Framework Directive and in Australia under the National Water Initiative.

There are five key areas where improvements in knowledge, science and monitoring of water resources in agriculture could help to better inform policy makers and the wider public.

- ***Improving the knowledge of the interrelationships between agriculture and water availability*** and the connection between surface water and groundwater flows.
- ***Increasing effort to establish robust databases on trends in water resource use*** by agriculture, as well data on the sources of water used, improved calculations of the physical and economic efficiency of water use in agriculture, and other information related to on-farm water use and the off-farm environmental consequences where water is recycled into the water system, including better quantifying the net costs and benefits of water resource use by agriculture (Chapter 2.1).
- ***Enhancing the quantity and quality of information on the cost recovery rates for water*** supplied to agriculture (Chapter 3.4.3). At present considerable caution is required in using and comparing data on cost recovery rates and agricultural water charges.
- ***Appreciating that climate change may render historical data on past trends of precipitation and temperature obsolete,*** hence, scientists and decision makers will need to be receptive to this problem in managing agriculture's use of water resources; moreover, policy makers will increasingly need to factor into their decision making the results from the extensive research underway in many OECD countries on climate change, agriculture and water resources (Chapter 3.5 and the OECD questionnaire at www.oecd.org/water).
- ***Encouraging greater evaluation of the cause and effect linkages between policies and environmental and economic outcomes in the context of agricultural water resource management,*** and as a contribution to broader based agri-environmental policy evaluation. Aside from academic research on these linkages, responses from member countries to an OECD questionnaire have revealed that there is little government evaluation of the environmental effectiveness and economic efficiency of agricultural water resource management policies (see the OECD questionnaire at www.oecd.org/water).

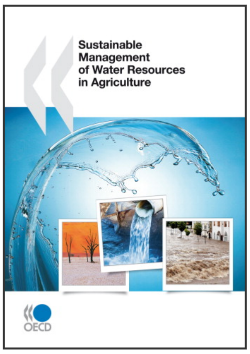
While there is a need to focus on the higher level policy settings around cost recovery targets and tariff structures, policy implementation and evaluation requires ***attention to the "soft" infrastructure*** – meters, stream gauging networks, hydrologic and scientific support, water reporting systems, farm surveys, and benchmarking of irrigation water businesses. As the policy settings become more sophisticated, the analysis and evaluation needs to be underpinned by good information (Parker and Speed, 2010).

Water entitlements and trading, moreover, requires real-time management of flows in rivers and detailed monitoring of extractions. In the longer term, a sustainable water entitlement system requires good science on river health and hydrologic performance, as well as assessments of the efficiencies of monopoly water businesses and the consequences of the reforms for agricultural production (perhaps the most important indicator of all). None of this information is obtained cheaply or easily, but without it reforms will falter (Parker and Speed, 2010).

There are also considerable needs for improved information in order that economic principles be put to best use in ensuring orderly maintenance of irrigation infrastructure. ***Information is needed on cost sharing arrangements*** between irrigators and public suppliers of irrigation, impacts on water savings at the project level as well as at the basin scale from infrastructure improvement. Robust data combined with judicious use of economic principles have considerable potential to productively inform decisions on how to best sustain irrigation infrastructure (Ward, 2010).

Notes

1. This chapter draws on responses from member countries to an OECD questionnaire covering water resource management in agriculture, and a number of OECD consultant reports, including: Cakmak (2010); Garrido and Calatrava (2010); Morris (2010); Nickum and Ogura (2010); Parker and Speed (2010); Ward (2010); Wichelns (2010b); and Young (2010), all available at www.oecd.org/water.
2. Discussion of agricultural support draws on Table 3.1; OECD (2008c); and the OECD questionnaire at www.oecd.org/water.
3. The focus of this section is on agriculture and flood risk management, as discussion of climate change projections and agriculture water consumption were examined in Chapter 2.2, while policy experience and responses to situations of agriculture, water scarcity and irrigation were the main focus of Chapter 3.2.



From:

Sustainable Management of Water Resources in Agriculture

Access the complete publication at:

https://doi.org/10.1787/9789264083578-en

Please cite this chapter as:

OECD (2010), “OECD Countries' Policy Experiences”, in *Sustainable Management of Water Resources in Agriculture*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/9789264083578-6-en