European Commission

Natural Water Retention Measures

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Individual NWRM

No till agriculture

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I. NWRM Description

Tillage is a mechanical modification of the soil. Intensive tillage can disturb the soil structure, thus increasing erosion, decreasing water retention capacity, reducing soil organic matter through the compaction and transformation of pores. No-till farming (also called zero tillage or direct drilling) is a way of growing crops or pasture from year to year without disturbing the soil through tillage. No-till is an agricultural technique which increases the amount of water that infiltrates into the soil and increases organic matter retention and cycling of nutrients in the soil. In many agricultural regions it can eliminate soil erosion. The most powerful benefit of no-tillage is improvement in soil biological fertility, making soils more resilient.

II. Illustration

Illustration 1: No-till seeder

Illustration 2: Maize planted without tillage

Source: http://www.commodityonline.com/news/zero-tilling--a-popular-alternative-farming-method-35479-3-35480.html

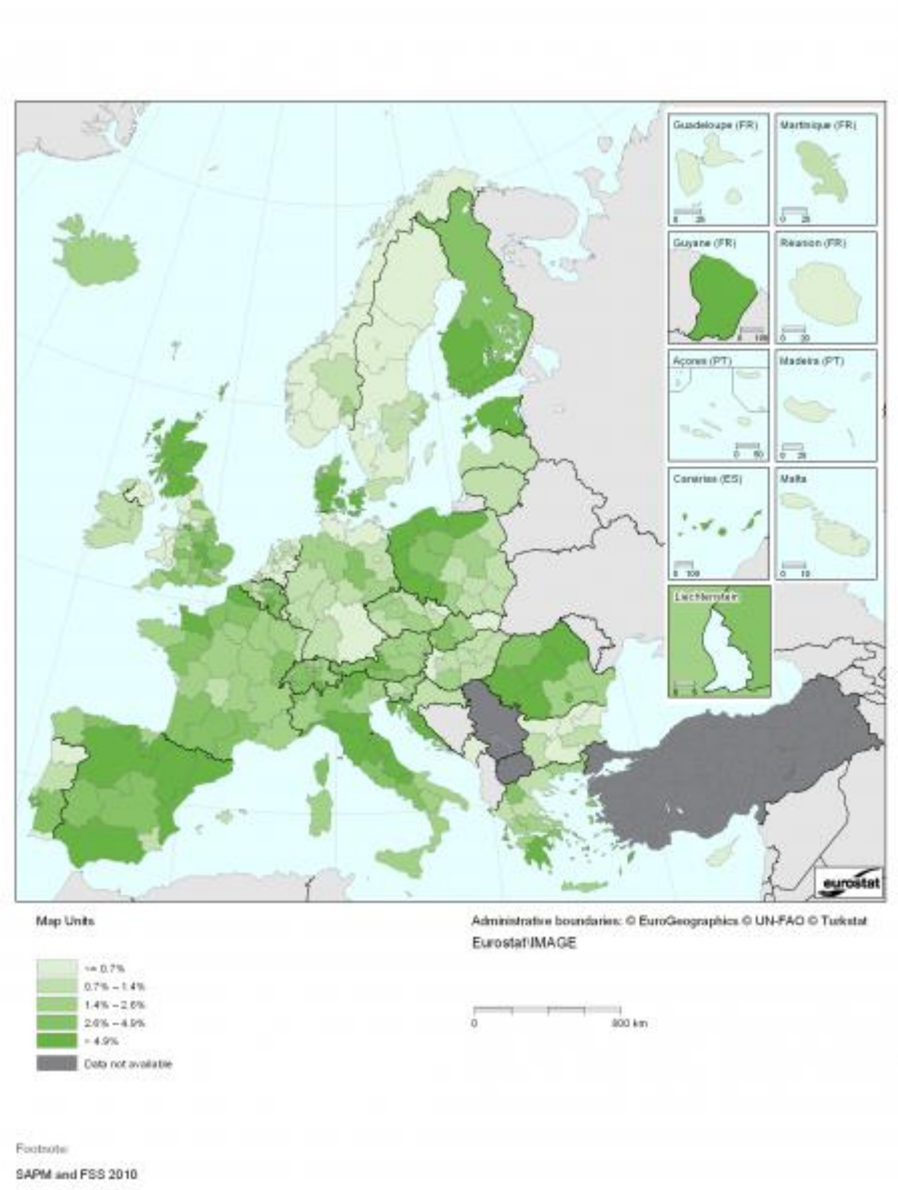
III.Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	No	Not applicable
Agricultural Areas	Yes	Arable land
Forests and Semi-Natural Areas	No	Not applicable
Wetlands	No	Not applicable

Region	Applicability	Evidence
Western Europe	Yes	Uptake of no-till in Northern and Western Europe has been limited due to the interaction of the number of factors: soil properties; machinery (e.g. harvest of potatoes and sugar beet); soil compaction; weather conditions; timeliness of sowing; weed control problems and residue management issues (Soane et al., 2012). These interacting factors mean that impacts of no-till on yield are variable. Uptake of no-till in selected countries as % of arable in 2010 (Eurostat): Belgium 2.7% Germany 1.2% Ireland 1.0% France 2.9% Luxembourg 0.7% Netherlands 0.7% United Kingdom 3.7%
Mediterranean	Yes	Use of no-till has increased in south-western Europe due to perceived environmental advantages and lower costs. Observed yields for winter-sown crops are either equal or increased for no-till compared to after ploughing. The combination of no-till and preservation of surface crop residues has improved soil and water conservation (Soane et al., 2012). Uptake of no-till in selected countries as % of arable in 2010 (Eurostat): Greece 1.9% Spain 6.2% Croatia 2.1% Italy 4.1% Cyprus 0.3%

Region	Applicability	Evidence
		Malta 0.0% Portugal 2.6% Slovenia 1.5%
Baltic Sea	Yes	There has been an increase in the use of no-till in Finland despite the predominance of spring-sowing which is considered less suitable for no-till (Soane et al., 2012). Uptake of no-till in selected countries as % of arable in 2010 (Eurostat): Denmark 5.6% Estonia 6.6% Latvia 1.0% Poland 3.7% Finland 7.4% Sweden 0.6%
Eastern Europe and Danube	Yes	Uptake of no-till in selected countries as % of arable in 2010 (Eurostat): Bulgaria 0.5% Czech Republic 1.6% Hungary 1.2% Austria 2.1% Romania 7.0% Slovakia 2.5%

A6: No till agriculture



Share of arable land on which zero-tillage is applied (source: Eurostat,

Source: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Agri-environmental_indicator_-_tillage_practices#Database

IV. Scale

	0-0.1km²	0.1-1.0km²	1-10km²	10-100km²	100-1000km²	>1000km²
Upstream Drainage Area/Catchment Area	✓	✓				
Evidence	This measure acts at field level and operation larger scales such as whole farms may be constrained by crop rotations where harvesting operations (e.g. for potatoes or sugar beet) limit potential for no-till in following crops (Soane et al., 2012). Implementation over larger areas would require significant coordination and incentive programmes.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	None	
	Slow Runoff	Negative	The case study 'Cover crops and no-tillage in an olive grove (Andalusia, Spain) reports a higher runoff coefficient of 11.9% for no tillage in comparison to conventional tillage. However the coefficient for conventional tillage (3.1%) was higher than for cover crops (1.2%).
	Store River Water	None	
	Slow River Water	None	
Reducing Runoff	Increase Evapotranspiration	None	
	Increase Infiltration and/or groundwater recharge	Low	Soane et al. (2012) note that no-till agriculture can increase infiltration rates although do not quantify this impact.
	Increase soil water retention	Medium	Bescansa et al. (2006) report soil water retention characteristics in the upper soil layer (0-0.15 m) across a range of matric potential of water values: • 0 kPa: 0.383 m3/m³ for no-till versus 0.431 m3/m3 for mouldboard tillage • -33 kPa: 0.366 versus 0.326 m3/m³ • -50 kPa: 0.319 versus 0.287 m3/m³ • 1500 kPa: 0.230 versus 0.217 m3/m³ Soane et al. (2012) report plant available water at

			different soil depths for a study in Germany: • 0–5 cm: 11.7 $m^3/100m^3$ for no-till versus 7.9 $m^3/100m^3$ for chisel-ploughed to 15 cm • 5–15 cm: 18.1 versus 14.8 $m^3/100m^3$ • 15–30 cm: 26.6 versus 20.9 $m^3/100m^3$ Runoff: 57mm with no till, 94 with ploughing (Italy) (Soane et al., 2012)
Reducing Pollution	Reduce pollutant sources	High	Biedermann (2013) 88% reduction in N concentration 50 (mulchseed) to 90% (direct drilling) herbicide loss in runoff reduction P loss with no till = 30% of the one with ploughing (Scandinavia) (Soane et al., 2012)
	Intercept pollution pathways	None	
Soil Conservation	Reduce erosion and/or sediment delivery	Medium	Soane et al. (2012) report reductions in soil erosion under no-till compared to ploughing: • 0.57 t/ha versus 2.1 t/ ha in Finland • 3 t/ha versus 28 t/ha for a hilly site near Pisa (Italy)
	Improve soils	High	Soane et al. (2012, Table 5) identify a number of advantages and disadvantages of no-till (within five or fewer seasons). Advantages: • Increased aggregate stability, especially near surface • Increased organic matter • Increased vertical and stable pore structure • Increased biological activity, especially earthworm (8-fold increase in numbers, 4.6-fold increase in biomass) • Increased infiltration rate • Increased hydraulic conductivity in subsoil • Increased soil strength and load bearing Disadvantages: • Increased bulk density at 0-25cm depth – poor aeration when wet • Increased moisture content near surface in spring in northern regions delaying drilling

<table>
<tr><td></td><td></td><td></td><td>Reduced soil surface temperature, especially in northern regions delaying drilling
Increased acidity near surface
Increased accumulation of P near surface with risks of loss in runoff</td></tr>
<tr><td rowspan="3">Creating Habitat</td><td>Create aquatic habitat</td><td>None</td><td></td></tr>
<tr><td>Create riparian habitat</td><td>None</td><td></td></tr>
<tr><td>Create terrestrial habitat</td><td>None</td><td></td></tr>
<tr><td rowspan="3">Climate Alteration</td><td>Enhance precipitation</td><td>None</td><td></td></tr>
<tr><td>Reduce peak temperature</td><td>None</td><td></td></tr>
<tr><td>Absorb and/or retain CO_2</td><td>High</td><td>This measure has a number of climate change interactions, this section considers only changes in soil organic carbon (SOC) levels. For soil fluxes, fuel use emissions and N_2O emissions see the Ecosystem Services Benefits Section.

Soane et al. (2012, Table 7) summarise the following results for SOC accumulation:

<table>
<tr><th>Country</th><th>Depth (cm)</th><th>Duration (years)</th><th>SOC change (kg C/ha/yr)</th></tr>
<tr><td>Scotland</td><td>0-60</td><td>6</td><td>0</td></tr>
<tr><td>Switzerland</td><td>0-40</td><td>19</td><td>0</td></tr>
<tr><td>Spain</td><td>0-40</td><td>13</td><td>158</td></tr>
<tr><td>France</td><td>0-20</td><td>32</td><td>162</td></tr>
<tr><td>Spain</td><td>0-40</td><td>15-18</td><td>20-187</td></tr>
<tr><td>England</td><td>0-30</td><td>5-9</td><td>340</td></tr>
<tr><td>Scotland</td><td>0-20</td><td>23</td><td>510</td></tr>
<tr><td>Portugal</td><td>0-30</td><td>4</td><td>750</td></tr>
<tr><td>Germany</td><td>0-30</td><td>3</td><td>1000</td></tr>
<tr><td>Spain</td><td>0-30</td><td>11</td><td>1000</td></tr>
<tr><td>Spain</td><td>0-30</td><td>10</td><td>1300</td></tr>
</table></td></tr>
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VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Food provision	Low, positive or negative	The impact of no-till system on crop yields is variable and may depend on context. Yield reductions may be offset with reduced production costs. Mulchseed: -4% to +3% Direct drilling: -11% to +12% (mean: -8%) (Biedermann, 2013) Pea-wheat-barley rotation : Tillage: 8.9 t/ha wheat + 5.4 t/ha pea + 7.5 t/ha barley No tillage: 9.6 t/ha wheat + 5.2 t/ha pea + 7.5 t/ha barley Wheat monoculture: Tillage: 8.2 t/ha No tillage: 8.1 t/ha wheat (Waligora, 2008) Yield: 4.07 to 4.13 t/ha for barley with no tillage 4.85 t/ha with reduced tillage 4.61 t/ha with mouldboard tillage (Bescansa, 2006) In Europe: yields 5% lower with no till than with tillage on average; in southern Europe (aridity), yields are higher with no tillage (López et al., 2012)
	Water Storage	None	
	Fish stocks and recruiting	None	
	Natural biomass production	None	
Regulatory and Maintenance	Biodiversity preservation	Medium	Number of earthworms increased by 8 fold following no-till and earthworm biomass under no till was 176gm^{-2} compared to 38 gm^{-2} under ploughing (Germany and Italy). Number of species of invertebrates increased from 26 to 34 species and that the total population numbers increased from 61 to 319 individuals with no till (Tunisia) (Soane et al., 2012)

	Climate change adaptation and mitigation	Medium, Positive or negative	Soane et al. (2012) report the findings of a study in north east Spain where CO_2 emissions from soil were 40% higher following ploughing than for no-till. Over the growing season microbial decomposition resulted in 20% higher CO_2 emissions for ploughed soils. However, as study in northern France found that over s 331-day period CO_2 emissions were 4064 and 3160 kg CO_2/ha for no-till and ploughed soil respectively. This higher emission was considered to be due to the presence of weathered residues on the soil surface during a dry period. Variability in soil CO_2 are due to water content, climate and amount, type and stratification of organic matter. CO_2 emissions from fuel use are lower in no-till systems compared to conventional tillage. One German study found no-till used 6.8 l/ha fuel compared to 43.55 l/ha for stubble cultivation, ploughing, secondary cultivation and sowing, as saving of 84% (Soane et al., 2012). Other studies report fuel savings between 50% and 83% (Soane et al., 2012); soil type is a key factor in the degree of fuel saving. A reduction fuel use of 40 l/ha would lead to a reduction in CO_2 emissions of 41 kg CO_2/ha. Multiple factors (soil type, wetness, aeration, compaction, temperature, fertiliser type, crops type) contribute towards N_2O emissions from soil, and there is considerable variability reported in studies of no-till systems (Soane et al., 2012): • France, good aeration, 11 months, 168 (±66) kg CO_2e/ha for no-till versus 102 (±19) kg CO_2e/ha • Denmark, medium aeration, 3 months 127 versus 263 kg CO_2e/ha • Scotland, poor aeration, 200 days, 7070 versus 2180 kg CO_2e/ha • England, poor aeration, 20 days, 1143 versus 900 kg CO_2e/ha The overall CO_2 budget in these studies for no-till compared to ploughing was: • France, +970 kg CO_2e/ha • Denmark, -1126 kg CO_2e/ha • Scotland, +4980 kg CO_2e/ha • England, +943 kg CO_2e/ha
	Groundwater / aquifer recharge	Medium	The stabilised earthworm and root channels of no-till soils contribute to increased hydraulic conductivity (Soane et al., 2012)

	Flood risk reduction	None	Flood risk reduction has not been directly quantified, but follows from increased water retention, infiltration and run-off reduction.
	Erosion / sediment control	High	Soil erosion with no-till 29% that with ploughing (570 versus 2100 kg ha-1) (Finland) Soil erosion on a hilly site near Pisa (Italy) was 3 t ha-1 for no-till compared to 28 t ha-1 under ploughing (Soane et al., 2012)
	Filtration of pollutants	Medium	The evidence on impact on nitrate leaching is mixed. In winter sown crops, rapid root growth in ploughed soil may encourage greater crop uptake of N resulting in lower leaching to groundwater relative to no-till soils. Poor establishment of no-till crops if autumn is dry might also increase leaching. For spring crops the lack of disturbance and presence of crop residues will discourage mineralisation resulting in lower leaching. The infiltration capacity of no-till soils need to be maintained to reduce the risk of P losses and eutrophication of water courses. (Soane et al., 2012)
Cultural	Recreational opportunities	None	
	Aesthetic / cultural value	None	
Abiotic	Navigation	None	
	Geological resources	None	
	Energy production	None	

VII. Policy Objectives

Policy Objective		Rating	Evidence
Water Framework Directive			
Achieve Good Surface Water Status	Improving status of biological quality elements	None	
	Improving status of physico-chemical quality elements	Medium	Soane et al. (2012) note that evidence on the impacts of no-till on N leaching is mixed and these vary depending on time of sowing and weather conditions. P losses may also occur if soil infiltration capacity is not maintained.

	Improving status of hydromorphological quality elements	Medium	No-till contributes to this objective through the reductions in soil erosion and consequent sediment delivery.
	Improving chemical status and priority substances	None	
Achieve Good GW Status	Improved quantitative status	Medium	The stabilised earthworm and root channels of no-till soils contribute to increased hydraulic conductivity (Soane et al., 2012)
	Improved chemical status	None	
Prevent Deterioration	Prevent surface water status deterioration	Medium	No-till contributes to this objective through the reductions in soil erosion and consequent sediment delivery.
	Prevent groundwater status deterioration	None	
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		Medium	Catchment level promotion of no-till together with other agricultural measures is likely to be necessary to impact on flood risks
Habitats and Birds Directives			
Protection of Important Habitats		None	
2020 Biodiversity Strategy			
Better protection for ecosystems and more use of Green Infrastructure		High	No-till contributes to this objective through the reductions in soil erosion and consequent sediment delivery.
More sustainable agriculture and forestry		Low	No-till offers a number of potential benefits that could contribute to sustainable agriculture; these are often when it is used in conjunction with other measures such as cover crops or controlled traffic farming. However, these benefits are often not consistent and negative impacts may arise due to conditions such as soil type and climate. Use of the measure may also be constrained by crop types.
Better management of fish stocks		None	
Prevention of biodiversity loss		Low	There is evidence of higher soil biodiversity that may in turn support wider biodiversity. Associated practices such as maintaining winter cover may also be beneficial.

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	
Space required	
Location	
Site and slope stability	
Soils and groundwater	
Pre-treatment requirements	
Synergies with Other Measures	
Design recommendations	No tillage can be combined with other agricultural measures. Those of particular relevance include green cover/cover crops, mulching, controlled traffic farming. Controlled traffic farming is especially relevant as it can help to avoid problems of soil compaction due to machinery movements in no-till systems, particularly on the wetter soils typical of northern Europe. (Soane et al., 2012)

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition	0	Measure is a change in land management practices and does not involve land acquisition
Investigations & Studies	0	Measure does not require pre-implementation studies
Capital Costs	Direct drilling (€) 10833	No-till systems require direct drilling machinery as an alternative to ploughing. If no-till is used in conjunction with winter cover crops, rollers may be necessary prior to drilling of spring crops. Machinery fixed cost given by Biedermann (2013) for a 100 ha case study farm in Austria, these are considerably lower than costs for a ploughing system, but would likely represent an additional cost to farmers changing to no-till.
Maintenance Costs	Fuel (€/ha): -30 – -67 Labour costs (€/ha): -21 Herbicide costs (€/ha): 5 – 18 Fertiliser costs (€/ha): 16	Operational costs for no-till are lower due to reduced fuel costs, e.g. 6.8 l/ha fuel compared to 43.55 l/ha for stubble cultivation, ploughing, secondary cultivation and sowing, a saving of 84% (Soane et al., 2012). Biedermann (2013) reports total fuel usage for winter wheat according to soil type: • Light: 37 l/ha for direct sowing versus 73 l/ha for ploughing = 36 l/ha reduction • Medium: 40 l/ha versus 96 l/ha = 56 l/ha reduction • Heavy: 42 l/ha versus 120 l/ha = 78 l/ha reduction Fuel costs based on 0.84 €/l[a] Soane et al. (2012) report a reduction in labour costs of €21/ha and up to €67/ha reduction in ploughing and cultivation costs. Biedermann (2013) reports additional herbicide and fertiliser costs for no-till of 18 €/ha and 15.75 €/ha (additional 15 kg N/ha at €1.05/kg) respectively. Biedermann estimates average total cost reductions of €24000 per farm for no tillage.
Additional Costs	0	

[a] Based on 0.70 £/l average diesel price quoted in the Economic Report on Scottish Agriculture 2014, converted at at £1 = €1.20.
http://www.scotland.gov.uk/Publications/2014/06/3709/4

X. Governance and Implementation

Requirement	Evidence
Farm advice and demonstration	Uptake of measures such as no-till involve uncertainty for farmers including potential trade-offs of yield and input costs. The full benefits may not be realised for several years post implementation. Demonstration of the benefits and advice to tailor the techniques to the circumstances of individual farms are important.

XI. Incentives supporting the financing of the NWRM

Type	Evidence
Rural Development payments for associated measures.	No-till is not directly supported as a measure in the 2007-13 Rural Development Programme. However, associated measures such as maintaining overwinter stubbles, i.e. not ploughing stubbles prior to spring sowing, are available. Payments for these across the EU average 128 €/ha with a range of 11 to 390 €/ha

XII. References

Reference
Basch G, Geraghty J, Streit B and Sturny W (2009) No-tillage in Europe – State of the Art: Constraints and Perspectives, No-Till Farming Systems, World Association for Soil and Water Conservation – Special Publication No. 3 (first published 2008 and updated in 2009)
Bescansa P, Imaz MJ, Virto I, Enrique A and Hoogmoed WB (2006) Soil water retention as affected by tillage and residue management in semiarid Spain, Soil & Tillage Research 87(1): 19–27
Biedermann,G., Economic aspects of mulch and direct seeding- reduction of soil treatment, which changes in the operational result have to be expected? 2013 Alterra 2005-2008 http://www.lko.at/mmedia/download/2013.07.15/1373878313334361.pdf (in German) Also reported in the 'No Tillage Field Trials in Lower Austria case study
Cover crops and no-tillage in an olive grove (Andalusia, Spain) case study
Eurostat Agricultural Statistics http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database
López MV, Blanco-Moure N, Ángeles Limón M and Gracia R (2012) No tillage in rainfed Aragon (NE Spain): Effect on organic carbon in the soil surface horizon, Soil & Tillage Research 118: 61–65

Soane BD, Ball BC, Arvidsson J, Basch G, Moreno F and Roger-Estrade J (2012) No-till in northern, western and south-western Europe: A review of problems and opportunities for crop production and the environment, Soil & Tillage Research 118: 66-87 A comprehensive review of the literature on the impacts of no-till including those on yields, soil properties and the environment.
Waligora C and Tetu T (2008) Légumnineuses il est urgent de les réhabiliter, Techniques Culturales Simplifées N°48. Juin/Juillet/Août 2008 Report on field tests at Boigneville, France (in French) http://agriculture-de-conservation.com/sites/agriculture-de-conservation.com/IMG/pdf/TCS_48_legumineuses.pdf