# Image captions

Image 1: First stage analysis of Scientist mental model

Image 2: Building a mental model with a farmer

Image 3: Complete digitised mental model of a Farmer

# Appendix A: Simplified mental models of scientists

should deliver

to secure

Functional biodiversity

**Scientist 1**

can inform

ESS

& long-term benefits

Farmer

buy-in demand

can support

external to

such as

should promote

limited evidence of

Sustainable Agricultural System

Agro-ecology as scientific discipline, underpinned by ecology

Habitat Amendment: e.g. flower strips, beetle banks

Ecological Engineering: e.g. IPM, rotations, GM crops, targeted spraying

Management strategies

Figure 1. Mental model of Scientist 1, an ecologist with an interest in pest regulation in farming systems. [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice]

**Scientist 2**

Interest in alternative nutrient sources

Chemical inputs

Organic

Conventional

Crop diversity, rotations

Growing legumes

Drive for high production

Certification, CAP greening req.

Figure 2. Mental model of Scientist 2, an environmental scientist with an interest in legumes and crop rotations. [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice]

**Scientist 3**

Yields

to maintain

to reduce

relies on

to enhance

reduces

reduced need for

Natural

pest control & pollination

Agro-chemical inputs

Biodiversity

Conventional farming

Ecological focus areas, field margins, crop diversity, weedy understory

Agro-ecology to redesign Agricultural Management Systems

Direct drilling

Better

soil quality,

less compaction

Compost

Figure 3. Mental model of Scientist 3, an ecologist with an interest in insect-crop interactions and forestry. [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice]

Figure 4. Mental model of Scientist 4, a plant scientist with an interested in agro-ecology and ecosystem services. [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice]

Pesticides

discourage

have low

could need fewer

Non-crop vegetation: Legumes, field margin, understory planting, beetle banks

Agro-ecology helps to develop sustainable agricultural practices

Economic sustainabi-lity

**Scientist 4**

Regulation could

Environ-mental sust-tainability

Yield reliability

New crop varieties

Chemical fertiliser

ensure

encourage

could reduce

undermines

Farm profits

**Scientist 5**

prioritises

Chemical pest/ disease control

Run-off

& erosion

Soil security

Biodiversity

Younger farmers & monitor farms

Nutrient levels

relies on

important for

aids in

preserves

improves

reduces

reduces

increases

may support uptake of

Tilling / cultivation

Agro-ecology (which still contradicts with native ecology)

Traditional agriculture

Targeted spraying & innovative technology

Continuous crop cover

Reduced traffic

Figure 5. Mental model of Scientist 5, a soil scientist with an interest in soil management in agriculture.

[Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice]

**Scientist 6**

Legumes & green manures

Biodiversity through rotations & mixtures

Reduce reliance on artificial fertiliser

Reduce pesticides

Cap greening requires

Agro-ecology
&
organic farming
as
Managed Ecosystem

Profits

Environmental benefits

should consider

Figure 6. Mental model of Scientist 6, a plant scientist with an interest in organic farming. [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice]

increases

**Scientist 7**

must provide

proof of advantage

Political / social accep-tability

Increases

diversity compared to mono-cropping

could be

used to develop

such as

Farmer acceptability

reducing

Rotations & inter-cropping

Agro-ecological theory & science

Alternative practices

reduces

Resilience

Trade-offs with yield

associated with

affects

reduces

increases

seek to

increase

increase

Alternative nutrient sources

Conventional N/P fertiliser

Figure 7. Mental model of Scientist 7, a plant physiologist with an interest in nutrients and rhizosphere dynamics. [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice]

**Scientist 8**

Soils in

complex interaction with farming interventions

Environment

use particular

seek to preserve

have less

negatively impact

require

use

rely on intensive

have impact on

needs

are bred to

suit particular

New rotations, mixture cropping, inter-cropping, cover crops

New farming systems that take a systems approach

Soil trait space

Ploughing / tilling

New crop varieties

Monitoring through farmers’ experience & precision equipment

Traditional plough-based systems

Figure 8. Mental model of Scientist 8, a molecular biologist with an interest in soil-root interactions. [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice]

# Appendix B. Simplified mental models of farmers

Alternative approaches

Tried min-till

Saves time

Rye in rotation

Deep

roots improve soil quality & yields

Requires

less fertiliser & fungicide

Reduced costs

Use local brewer’s yeast as feed

Low

food miles,

low carbon

footprint

Replaces fertiliser

Spreading slurry

Straw in slurry

Organic

matter & soil structure

Extra

income from poor land

Water margins

**Farmer 1**

Figure 9. Mental model of Farmer 1, an intensive mixed pig and arable farmer (360 sows and 300 ha arable). [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice

Ease of operation

**Farmer 2**

Inputs & costs

Requires

very little land comp’d to AD plant

Traffic / compaction

Pollination & wildlife

Water quality

Improved

aesthetics & opp’s for recreation

Less

investment & income from wood harvest

encourages

improves

reduces

reduces

Tree planting

Water margins

Alternative approaches & agri-environment schemes

Species rich grassland, beetle banks & hedges

Wind turbine

GPS/ precision farming

Figure 10. Mental model of Farmer 2, a small arable farmer (150 ha). [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice

Improved

harvest times & disease resistance &

spread risk

**Farmer 3**

obligatory

Leave low yield areas fallow

Higher returns

Reduces

inputs 🡪prolongs chemical

efficacy

Greening measures, including margins buffers & fallows

Premium prices

Precision agriculture

Alternative approaches

GPS / soil mapping, variable rate input application

Yield mapping

Optimise inputs & even crop

New crop varieties

Agri-environmental schemes

Figure 11. Mental model of Farmer 3, a large arable, contract farmer (1500 ha). [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice].

Figure 12. Mental model of Farmer 4, an extensive mixed cattle, sheep and arable farmer (90 ha, 70 cattle, 200 ewes, and 500 lambs for finishing). [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice].

improves

**Farmer 4**

Provides disease buffer

Increases soil organic matter

Requires

less fertiliser, less feed

Free fence

Wind break

Accurate fertiliser distribution

Livestock outcomes & crop yields

such as

scheme offered

Traditional 7-year ‘turnip’ Townshend rotation: wheat, turnips, barley/clover, grass & stock of sheep

Woodland and hedges

Precision agriculture

Soil analysis, GPS, nutrient budgeting

Alternative approaches such as low external input system

Not very profitable on fertile land

Precision farming: Variable seeding, liming, P and K

Lighter machinery

**Farmer 5**

Did not lead to

Has tried

Min-till

Even crop, high yield

Wind energy

Reliable income

Aids in pest/disease management

Reduces

agri-chemical inputs

Based on

Interest in

Integrated farm management

Crop rotation

Figure 13. Mental model of Farmer 5, a medium arable farmer (420 ha total, some suckler cows). [legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; rectangle; rounded rectangle is a practice].

Alternative approaches seen as improving nutrient cycling

Increases

wildlife, reduces labour req.

**Farmer 6**

location for

Umbilical

pump increases efficiency

Reduces

chemical inputs & food miles

Improved self-sufficiency

Increases yields

Responds

to market needs

Reduces reliance on anti-biotics

Reduces

costs, increases efficiency

Precision farming

Arable side

Pig side

Precision farming

N monitoring & soil testing

Benchmarking

Monitoring of individual animals

Renewable energy

Smart application of slurry

Set aside land

Figure 14. Mental model of Farmer 6, an intensive mixed pig and arable farmer (450 sows and 170 ha arable). [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice].

Premium prices

Build natural resistance in animals

**Farmer 7**

Addresses

social concerns, e.g. BSE

Habitats: margins, weeds, ponds

Less N pollution

Health benefits for consumer

No chemical N application

Reduction in pesticides

Reduced use of anti-biotics

Organic, extensive farming approach

Sward with clover

More protein in feed

More omega-3 in milk

Wildlife

better chance

instead

requires

contributes

to

pre-condition for

limits scope for

Figure 15. Mental model of farmer 7, an organic dairy farmer (160 ha) with 160 cows. [Legend of shapes: rectangle is concept/system; diamond is advantage/mediating factor; circle is disadvantage; rounded rectangle is a practice].