

The ERAMMP Integrated Modelling Platform

Llwyfan Modelu Integredig ERAMMP

The ERAMMP Integrated Modelling Platform (IMP) is a computer model that simulates the potential effects of government policies on agriculture and the natural environment in Wales.

The IMP has been jointly designed by the ERAMMP consortium and the Welsh Government. It has been specifically tailored to provide information to support the development of new policies focused on natural resource management, land use and agriculture under a range of Welsh economic and regulatory futures. The IMP allows emerging policy ideas to be explored and stress-tested prior to final design and implementation.

The IMP comprises a chain of specialised, state-of-the-art models customised (as best as possible) with Welsh data. These models cover **agriculture, forestry, land use allocation, biodiversity and a range of ecosystem services** (including water quality, air quality, greenhouse gas emissions/carbon sequestration) and their valuation. The IMP takes an integrated approach that recognises that policy effects in one sector have indirect effects in other sectors. In this way, the IMP explicitly accounts for biophysical and socio-economic interactions between sectors.

The model is designated as business critical by Welsh government and, as a result, it complies with the stringent quality assurance processes of the UK government Aqua Book. This includes a focus on transparency with respect to the assumptions that underpin the model and a critical assessment of how the model results should and should not be interpreted.

The ERAMMP IMP is an invaluable tool for exploration and stress-testing ideas in an integrated manner. However, it is only one part of the information WG use to support their decisions. The transparent, self-critical, iterative approach is essential to highlight where information from others sources is needed to contextualise the decisions made.



Mae Llwyfan Modelu Integredig (IMP) ERAMMP yn fodel cyfrifiadurol sy'n efelychu effeithiau posibl polisïau'r llywodraeth ar amaethyddiaeth a'r amgylchedd naturiol yng Nghymru.

Mae'r IMP wedi'i gyd-ddylunio gan gonsortïwm ERAMMP a Llywodraeth Cymru. Mae wedi'i deilwra'n benodol i ddarparu gwybodaeth i gefnogi datblygiad polisïau newydd sy'n canolbwyntio ar reoli adnoddau naturiol, defnydd tir ac amaethyddiaeth o dan amrediad o ddyfodolau economaidd a rheoleiddiol Cymru. Mae'r IMP yn caniatáu archwilio a phrofi straen syniadau polisi sy'n dod i'r amlwg cyn eu dylunio'n derfynol a'u gweithredu.

Mae'r IMP yn cynnwys cadwyn o fodelau arbenigol o'r radd flaenaf wedi'u haddasu (cystal â phosibl) yn ôl data Cymru. Mae'r modelau hyn yn ymdrin ag amaethyddiaeth, coedwigaeth, dyraniad **defnydd tir, bio-amrywiaeth ac amrediad o wasanaethau ecosystem** (gan gynnwys ansawdd dŵr, ansawdd aer, allyriadau nwyon tŷ gwyr/atafelu carbon) a'u prisio. Mae'r IMP yn mabwysiadu ymagwedd integredig sy'n cydnabod bod gan effeithiau polisi mewn un sector effeithiau anuniongyrchol mewn sectorau eraill. Yn y modd hwn, mae'r IMP yn cyfrif yn benodol am y rhyngweithio bioffisegol ac economaidd-gymdeithasol rhwng sectorau.

Mae'r model wedi'i ddynodi'n hanfodol i fusnes gan Lywodraeth Cymru ac, o ganlyniad, mae'n cydymffurfio â phrosesau llym sicrhau ansawdd Aqua Book llywodraeth y DU. Mae hyn yn cynnwys ffocws ar dryloywder o ran y rhagdybiaethau sy'n sail i'r model ac asesiad beirniadol o sut y dylai ac na ddylai canlyniadau'r model gael eu dehongli.

Mae IMP ERAMMP yn offeryn amhrisiadwy am archwilio a phrofi straen syniadau mewn modd integredig. Fodd bynnag, mae'n rhan yn unig o'r wybodaeth mae Llywodraeth Cymru yn ei defnyddio i gefnogi eu penderfyniadau. Mae'r ymagwedd dryloyw, hunan-feirniadol, ailadroddol yn hanfodol i amlygu ble mae angen gwybodaeth o ffynonellau eraill er mwyn rhoi'r penderfyniadau a wneir yn eu cyd-destun.

The IMP development is led by UKCEH in partnership with Cranfield University, Forest Research, RSK ADAS, BTO and eftec; working closely with the Welsh Government.

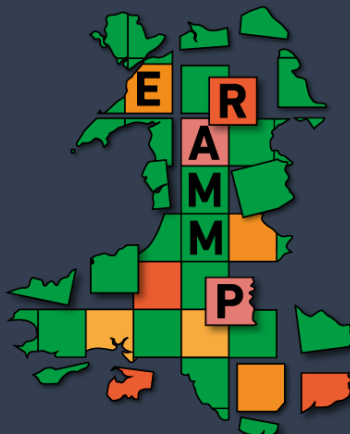
Mae datblygiad yr IMP yn cael ei arwain gan UKCEH mewn partneriaeth â Phrifysgol Cranfield, Forest Research, RSK ADAS, BTO ac eftec; gan weithio'n agos gyda Llywodraeth Cymru.

Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

The Welsh environment supports significant economic sectors including agriculture, fisheries, tourism and forestry and are of importance to other policy areas including health and well-being, energy and infrastructure.

In order to develop policies that build social, economic and environmental resilience and to evaluate programme implementation, the Welsh Government requires a robust **Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)**.

The overall aim of ERAMMP is to deliver a programme of monitoring and modelling which collects data across the Welsh landscape and links any changes to their impacts on a wide range of benefits including their economic consequences. The programme will be a key source of data for future editions of the State of Natural Resources Report (SoNaRR). The programme will also undertake modelling for the EU exit process and the design and evaluation of programmes delivering to the Natural Resources Policy.



Rhaglen Monitro a Modelu'r Amgylchedd a Materion Gwledig ('ERAMMP')

Mae amgylchedd Cymru yn cefnogi sectorau economaidd arwyddocaol gan gynnwys amaethyddiaeth, pysgodfeydd, twristiaeth a choedwigaeth ac mae'n bwysig i feysydd polisi eraill gan gynnwys iechyd a llesiant, ynni a seilwaith. Er mwyn datblygu polisiâu sy'n cynnal cydnherthedd cymdeithasol, economaidd ac amgylcheddol ac i werthuso gweithrediad y rhaglen, mae'n ofynnol bod gan Lywodraeth Cymru **Raglen gadarn ar gyfer Monitro a Modelu'r Amgylchedd a Materion Gwledig**.

Nod cyffredinol y ERAMMP yw darparu rhaglen monitro a modelu sy'n casglu data ar draws tirwedd Cymru ac yn cysylltu unrhyw newidiadau â'u heffeithiau ar ystod eang o fuddion gan gynnwys y canlyniadau economaidd. Bydd y rhaglen yn ffynhonnell allweddol o ddata ar gyfer rhifynnau o'r Adroddiad ar Sefyllfa Adnoddau Naturiol (SoNaRR) yn y dyfodol. Yn ogystal, bydd y rhaglen yn gwneud gwaith modelu ar gyfer y broses o adael yr Undeb Ewropeaidd ac yn dylunio a gwerthuso'r rhaglenni sy'n cyflawni'r Polisi Adnoddau Naturiol.

www.erammp.wales

www.erammp.cymru

Alignment of the IMP to Policy Objectives

The main aim of the IMP is to inform policy development by providing rapid, integrated assessments of the impacts of changing policy or economic scenarios on agriculture and the environment.

The IMP has been used to investigate the impacts of post EU Exit trade deals on land use, agriculture and public goods / ecosystem services. It is being further adapted to directly support the development of the Sustainable Farming Scheme (SFS); Welsh Government's replacement to the EU's Common Agricultural Policy.

Policy interventions (such as changes in agricultural subsidies and scheme payments) and external drivers (such as changes in commodity prices due to new trading relationships) serve as inputs for the IMP, alongside other environmental and socio-economic variables.

Application of multiple scenarios (consisting of consistent changes in a range of inputs) enable rapid exploration of their impacts on agricultural, socio-economic, and public goods/ecosystem service outcomes.

Where possible, the integrated and rapid exploration of natural resource policy and land management under a range of future scenarios are aligned to Welsh Government policy objectives including:

- Climate change mitigation and adaptation
- Woodland planting and the national forest
- Reversing the decline in biodiversity
- Improving water quality
- Improving air quality
- Improving public health & wellbeing
- Sustainable agricultural productivity
- Sustainable management of natural resources
- Improvement of the natural landscape
- Conservation of heritage
- Improving social outcomes (e.g. public access, outdoor recreation).

Alinio'r IMP i Amcanion Polisi

Nod pennaf yr IMP yw llywio datblygiad polisi drwy gynnig asesiadau cyflym, integredig o effeithiau newid polisi neu senarios economaidd ar amaethyddiaeth a'r amgylchedd.

Mae'r IMP wedi'i ddefnyddio i ymchwilio i effeithiau cytundebau masnach yn dilyn ymadael â'r UE ar ddefnydd tir, amaethyddiaeth a nwyddau cyhoeddus / gwasanaethau ecosystem. Mae'n cael ei addasu ymhellach i gefnogi datblygiad y Cynllun Ffermio Cynaliadwy (CFfC) yn uniongyrchol; cynllun Llywodraeth Cymru i gymryd lle Polisi Amaethyddol Cyffredin yr UE.

Mae ymyriadau polisi (fel newidiadau mewn cymorthdaliadau amaethyddol a thaliadau cynlluniau) a chymhellion allanol (fel newidiadau mewn prisiau nwyddau oherwydd perthnasoedd masnachu newydd) yn fewnbynnau ar gyfer yr IMP, ynghyd â newidynnau amgylcheddol ac economaidd-gymdeithasol eraill.

Mae cymhwyso senarios lluosog (sy'n cynnwys newidiadau cyson mewn amrediad o fewnbynnau) yn galluogi archwilio ar garlam eu heffeithiau ar ganlyniadau amaethyddol, economaidd-gymdeithasol, a nwyddau cyhoeddus/ gwasanaethau ecosystem.

Lle bo modd, mae archwiliad integredig a chyflym polisi adnoddau naturiol a rheolaeth tir o dan amrediad o senarios y dyfodol yn cyd-fynd ag **amcanion polisi Llywodraeth Cymru** gan gynnwys:

- Lliniaru newid hinsawdd ac addasu
- Plannu coetiredd a'r goedwig genedlaethol
- Gwyrddroi'r dirywiad mewn bio-amrywiaeth
- Gwella ansawdd dŵr
- Gwella ansawdd aer
- Gwella iechyd a llesiant y cyhoedd
- Cynhyrchedd amaethyddol cynaliadwy
- Rheoli adnoddau naturiol yn gynaliadwy
- Gwella'r tirwedd naturiol
- Cadwraeth treftadaeth
- Gwella canlyniadau cymdeithasol (e.e. mynediad cyhoeddus, gweithgareddau hamdden awyr agored).

IMP Outputs

The IMP enables integrated rapid assessment of natural resource policy options. The model assesses changes in:

- Farm type and profitability
- Agricultural income
- Agricultural production
- Land use and livestock numbers
- Suitability of species populations for plants and birds
- Woodland habitat connectivity
- Woodland productivity and harvested wood products
- Carbon in soils, vegetation and biomass
- GHG emissions from land use, land use change and forestry, agriculture and peat
- Water quality (nitrate, phosphorus and sediment load)
- Water framework Directive P status and drinking water N status
- Air quality (PM2.5 concentration and effects on human health)
- Values across a range of public goods / ecosystem services over 5, 25 and 75 years

Allbynnau'r IMP

Mae'r IMP yn galluogi asesiad cyflym integredig o opsiynau polisi adnoddau naturiol. Mae'r model yn asesu newidiadau mewn:

- Math a phroffidoldeb ffermydd
- Incwm amaethyddol
- Cynhyrchedd amaethyddol
- Defnydd tir a niferoedd da byw
- Addasrwydd poblogaethau rhywogaethau ar gyfer planhigion ac adar
- Cysylltedd cynefinoedd coetir
- Cynhyrchedd coetir a chynhyrchion pren a gynaeafir
- Carbon mewn priddoedd, llystyfiant a biomas
- Allyriadau nwyon tŷ gwydr o ddefnydd tir, newid defnydd tir a choedwigaeth, amaethyddiaeth a mawn
- Ansawdd dŵr (llwyth nitradau, ffosfforws a gwaddodion)
- Statws P y Gyfarwydddeb fframwaith dŵr a statws N dŵr yfed
- Ansawdd aer (cryodiadau PM2.5 ac effeithiau ar iechyd dynol)
- Gwerthoedd ar draws amrediad o nwyddau cyhoeddus / gwasanaethau ecosystem dros 5, 25 a 75 o flynyddoedd

IMP Spatial Resolution and Presentation

The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated (e.g. sub-farm, farm, catchment).

The finest spatial resolution that is used for simulating farm type and land use transitions is the Decision-Making Unit (DMU).

A DMU is sub-farm (often field-scale) defined as a managerially homogenous cluster of soil type, rainfall and land cover.

The modelling outputs are generally presented graphically on maps. Summary level data is available in addition to analysis at sub-national level.

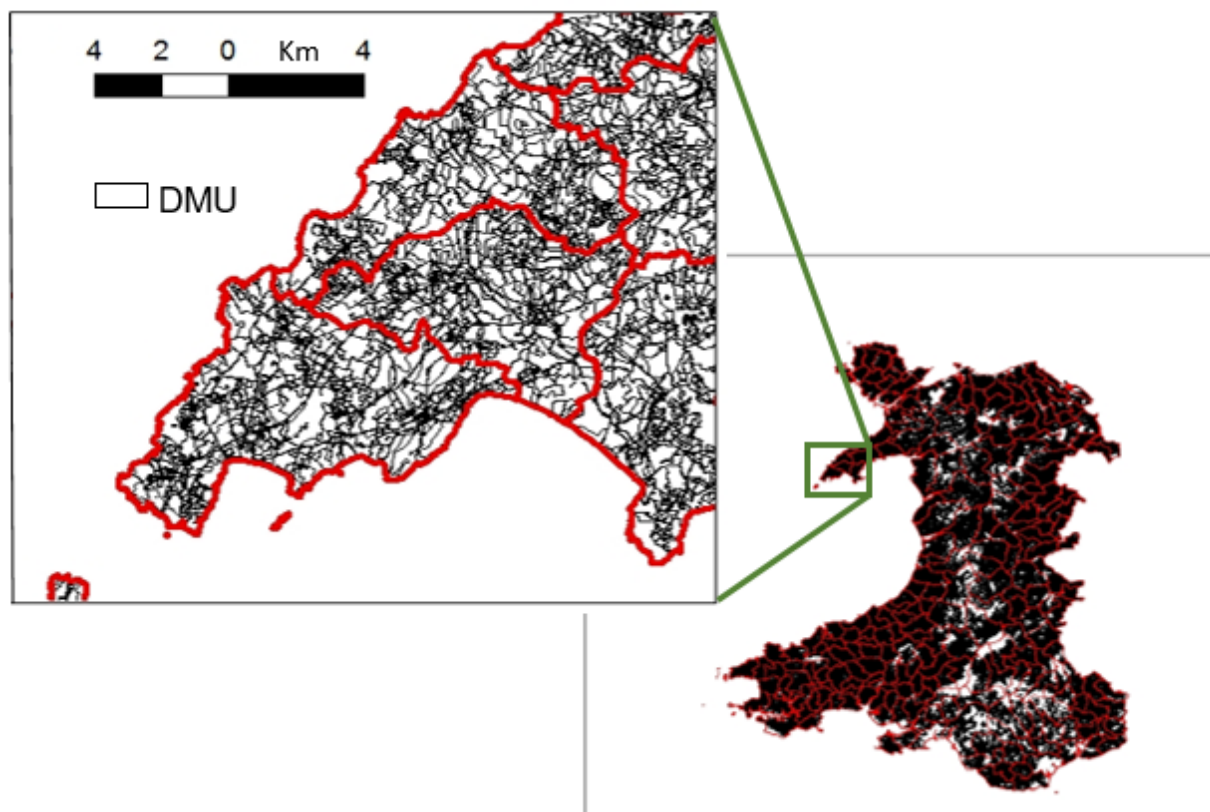
Cydraniad Gofodol a Chyflwyniad yr IMP

Mae'r IMP yn gweithredu ar amrywiol gydraniadau gofodol yn dibynnu ar ba raddfa sy'n fwyaf priodol i'r dangosydd sy'n cael ei efelychu (e.e. is-fferm, fferm, dalgylch).

Defnyddir y cydraniad gofodol meinaf i efelychu trosiannau math o fferm a defnydd tir yn yr Uned Benderfynu (UB).

Mae UB yn is-fferm (graddfa caeau yn aml) a ddiffinnir fel clwstwr o fathau pridd, glawiad a gorchudd tir a reolir yn unfurf.

Fel arfer cyflwynir allbynnau'r modelu yn raffigol ar fapiau. Mae data lefel cryno ar gael yn ogystal â dadansoddiad ar lefel is-genedlaethol.



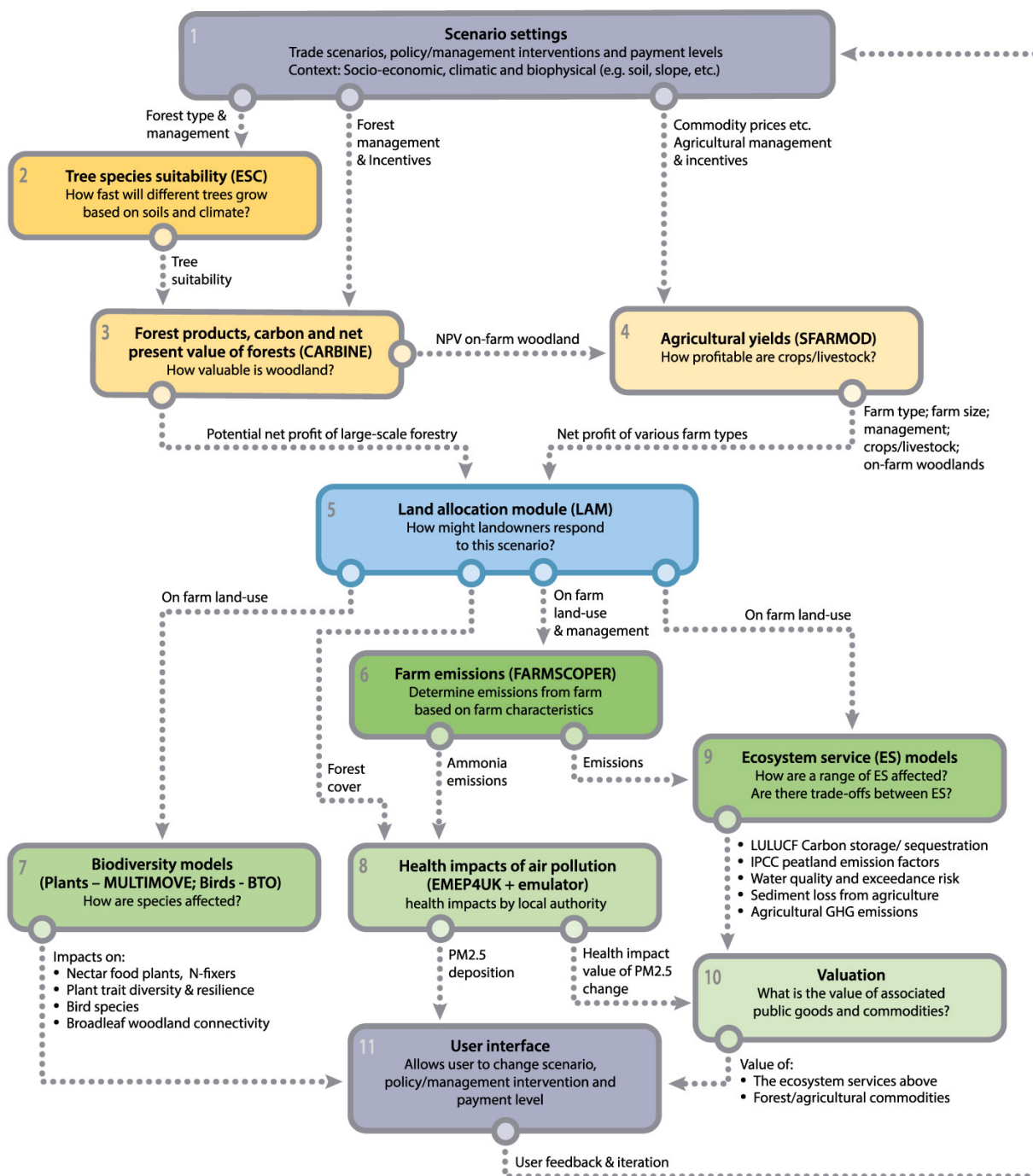
IMP's Integrated Model Architecture

The nature of decision-making around land management, agriculture and the environment is inherently complex due to the range of interdependencies between different sectors and the varied actors within them. The problem faced by many traditional modelling approaches is that they address these sectoral challenges independently without being able to explicitly represent the implications for other sectors.

To address this challenge of sectoral interdependence the IMP has been developed as an integrated system of 11 inter-connected models. The models have been linked together by establishing data-flows between models across a model chain. These data-flows represent the interdependencies between different sectors or impacts. The model chain is run for a range of scenarios whose settings are co-created with the relevant Welsh Government policy team. Outputs from the model chain are ingested into a user interface, which is being designing with Welsh Government to enable interactive exploration of the results.

The components of the Integrated Modelling Platform are

- Box 1 Input scenarios and parameters.
- Box 2 Ecological Site Classification (ESC)¹ is a decision support system (DSS) tool estimating suitability for a range of tree species, driven by climate and site condition.
- Box 3 CARBINE^{2,3} is an analytical forest sector carbon accounting model and forecasting model for tree growth and timber production.
- Box 4 SFARMOD (Silsoe Whole Farm Model)⁴ is a mechanistic linear program of long-term farming which optimises land use based on profit maximisation or weighted multiple objectives.
- Box 5 Land Allocation Module (LAM) projects changes to land uses through a set of rules and thresholds; comparing a current farm type with the most profitable alternative farm type.
- Box 6 FARMSCOPER tool⁵ integrates calculations of pollutant emissions with mitigation measure cost and effectiveness for prioritisation of mitigation measures across multiple pollutants.
- Box 7 Ecosystem service models simulate a range of ecosystem services based on changes in land use, climate and other drivers. Specifically, carbon sequestration from land use, land use change and forestry, GHG emissions from agriculture and peatlands, and water quality.
- Box 8 Biodiversity Models:
 - a) MultiMOVE^{6,7,8} estimates effects of climate, fertility, alkalinity, etc. on habitat suitability for plant and lichen species.
 - b) BTO models^{9,10}: National-scale pattern analyses using grid square data (1km) for simulating distribution, abundance and population changes for a range of terrestrial breeding bird species.
 - c) Broadleaf woodland connectivity model based on the distance species can travel (dispersal distance) and minimum habitat area requirements (patch size).
- Box 9 Health impacts of Air pollution: a meta-model based on the EMEP4UK atmospheric chemistry transport modelling system ^{11,12,13,14}, which simulates air pollutant concentrations and deposition in response to land use change.
- Box 10 Valuation – the valuation of the outputs of other models; specifically the ecosystem services and public goods, valued using monetary or non-monetary methods.
- Box 11 User interface: Graphical interface for exploring the IMP map and graph-based outputs.



Simplified schematic displaying the component models of the Integrated Modelling Platform and the links between them. Boxes represent either inputs, component models or the user interface. Arrows represent the flow of data, with text illustrating the types of data being passed between models.

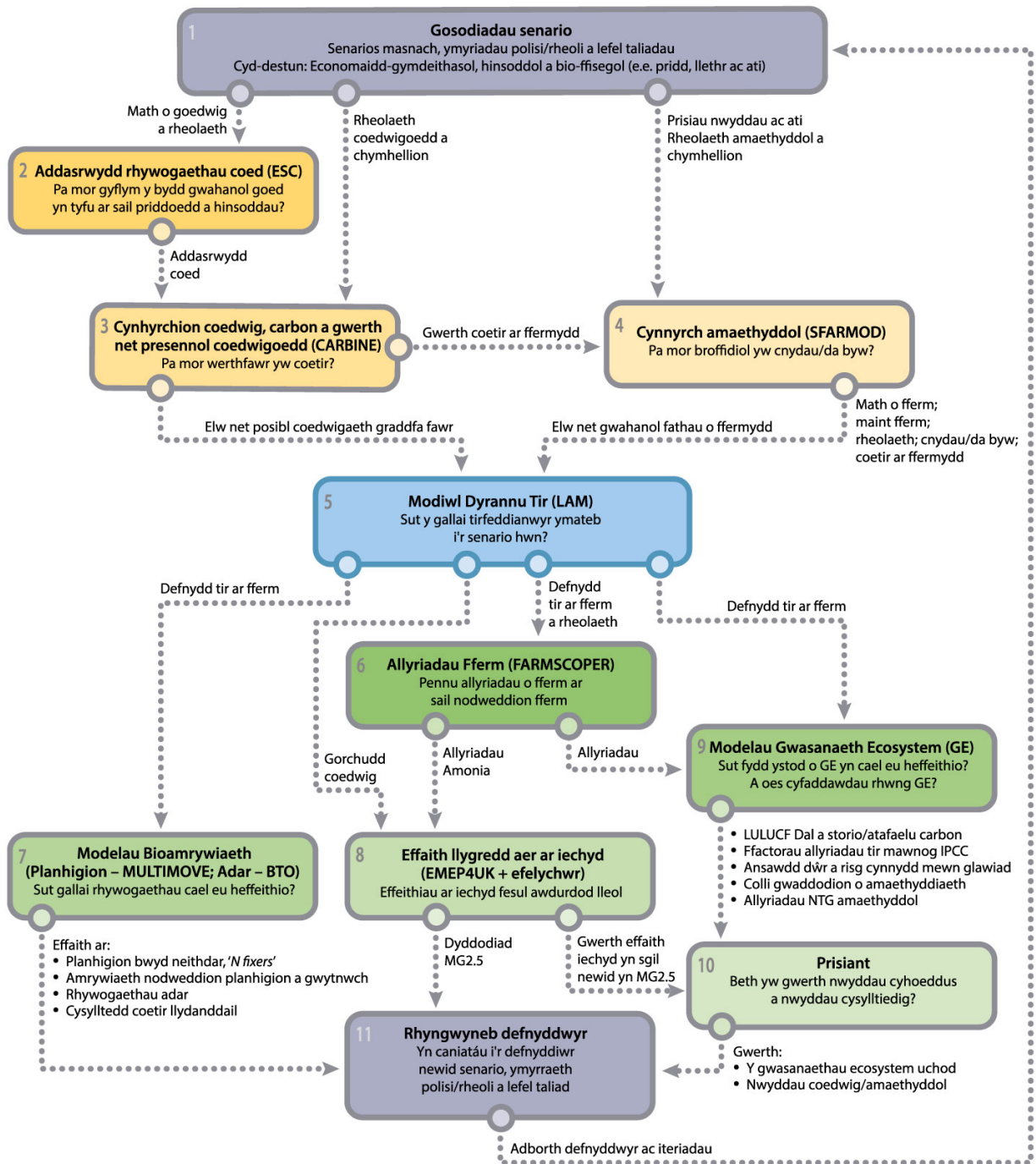
Pensaernïaeth Model Integredig yr IMP

Mae natur penderfyniadau mewn perthynas â rheoli tir, amaethyddiaeth a'r amgylchedd wrth reswm yn gymhleth gydag amrediad o ryngweithiadau cymhleth rhwng sectorau gwahanol a'r actorion amrywiol sydd ynddynt. Y broblem a wynebwr gan lawer o ddulliau modelu traddodiadol yw eu bod yn ymdrin â'r heriau sectorol hyn yn annibynnol heb allu cynhyrchioli'n benodol y goblygiadau ar gyfer sectorau eraill.

I fynd i'r afael â her hon rhyngddibyniaeth sectorol, mae'r IMP wedi'i ddatblygu'n system integredig o 11 model rhyng-gysylltiedig. Mae'r modelau wedi'u cysylltu â'i gilydd drwy sefydlu llifioedd data rhwng modelau ar draws gadwyn fodolau. Mae'r llifioedd data hyn yn cynrychioli'r rhyngddibyniaethau rhwng gwahanol sectorau neu effeithiau. Mae'r gadwyn fodolau yn cael ei rhedeg am amrediad o senarios y mae eu cyd-destunau'n cael eu cyd-greu gyda thîm polisi perthnasol Llywodraeth Cymru. Mae allbynnau o'r gadwyn fodolau'n cael eu porthi i ryngwyneb defnyddwyr, sy'n cael ei ddylunio gan Lywodraeth Cymru i alluogi archwilio'r canlyniadau mewn modd rhyngweithiol

Cydrannau'r Llwyfan Modelu Integredig yw:

- Bocs 1 Senarios a pharamedrau'r mewnbwn.
- Bocs 2 Mae Dosbarthiad Safle Ecolegol (DSE) ¹ yn system cefnogi penderfyniadau (SCP) sy'n amcangyfrif addasrwydd am amrediad o rywogaethau coed, wedi'i ysgogi gan hinsawdd a chyflwr safle.
- Bocs 3 Mae CARBINE ^{2,3} yn fodel dadansodol cyfrifo carbon y sector coedwigaeth ac yn fodel rhagfynegi am dwf coed a chynhyrchu pren.
- Bocs 4 Mae SFARMOD (Model Fferm Gyfan Silsoe) ⁴ yn rhaglen linellol fecanistig ffermio hirdymor sy'n optimeiddio defnydd tir ar sail uchafu elw neu amcanion lluosog wedi'u pwysoli.
- Bocs 5 Mae'r Modiwl Dyrannu Tir (MDT) yn rhagamcanu newidiadau i ddefnyddiau tir trwy set o reolau a throthwyon; yn cymharu math presennol o fferm â'r math amgen o fferm fwyaf proffidiol.
- Bocs 6 Mae offeryn FARMSCOPER ⁵ yn integreiddio cyfrifiadau allyriadau llygryddion â chost ac effeithiolrwydd mesurau lliniaru i flaenoriaethu mesurau lliniaru ar draws llygryddion lluosog.
- Bocs 7 Mae modelau gwasanaethau ecosystem yn efelychu amrediad o wasanaethau ecosystem ar sail newidiadau mewn defnydd tir, hinsawdd ac ysgogiadau eraill. Yn benodol, atafaelu carbon o ddefnydd tir, newid defnydd tir a choedwigaeth, allyriadau nwyon tŷ gwydr o amaethyddiaeth a mawndiroedd, ac ansawdd dŵr.
- Bocs 8 Modelau Bioamrywiaeth:
 - a) Mae MultiMOVE^{6,7,8} yn amcangyfrif effeithiau hinsawdd, ffrwythlondeb, alcalinedd, ac ati ar addasrwydd cynefinoedd ar gyfer rhywogaethau planhigion a chen.
 - b) Modelau YAB^{9,10}: Dadansoddiadau patrwm ar raddfa genedlaethol gan ddefnyddio data sgwariau grid (1km) am efelychu dosbarthiad, helaethrwydd a newidiadau poblogaeth am amrediad o rywogaethau adar bridio daearol.
 - c) Model cysylltedd coetir llydanddail ar sail y pellter y gall rhywogaethau deithio (pellter gwasgaru) a'r isafswm gofynion ardaloedd cynefin (maint ardal).
- Bocs 9 Effeithiau iechyd llygredd Aer: meta-model seiliedig ar system modelu trafndiaeth cemeg atmosfferig EMEP4UK ^{11,12,13,14}, sy'n efelychu crynodiadau a gwaddodi llygryddion aer mewn ymateb i newid defnydd tir.
- Bocs 10 Priso – priso allbynnau modelau eraill; yn benodol gwasanaethau ecosystem a nwyddau cyhoeddus, wedi'u priso gan ddefnyddio dulliau ariannol neu anariannol.
- Bocs 11 Rhyngwyneb defnyddwyr: Rhyngwyneb graffigol am archwilio map yr IMP a'r allbynnau ar ffurf graff.



Amlinelliad wedi'i symleiddio sy'n dangos modelau cydrannol y Llwyfan Modelu Integredig a'r cysylltiadau rhyngddynt. Mae'r blychau'n cynrychioli naill ai mewnbynnau, modelau cydrannol neu'r rhyngwyneb defnyddwyr. Mae saethau'n cynrychioli'r llif data, gyda'r testun yn dangos y mathau o ddata sy'n cael eu trosglwyddo rhwng modelau.

The Land Allocation Module (LAM)

Most of the models in the Integrated Modelling Platform have a long-standing history of use in environmental contexts. Alternatively, the Land Allocation Model (LAM) has been custom-developed with the Welsh Government to best reflect on-farm decision-making in Wales. In broad terms, the LAM simulates how land managers might respond to the various options for land use and land management provided by the forestry and agricultural models. It then passes this information to the biodiversity and ecosystem service models to simulate the consequences of these changes in land use and land management on the wider environment.

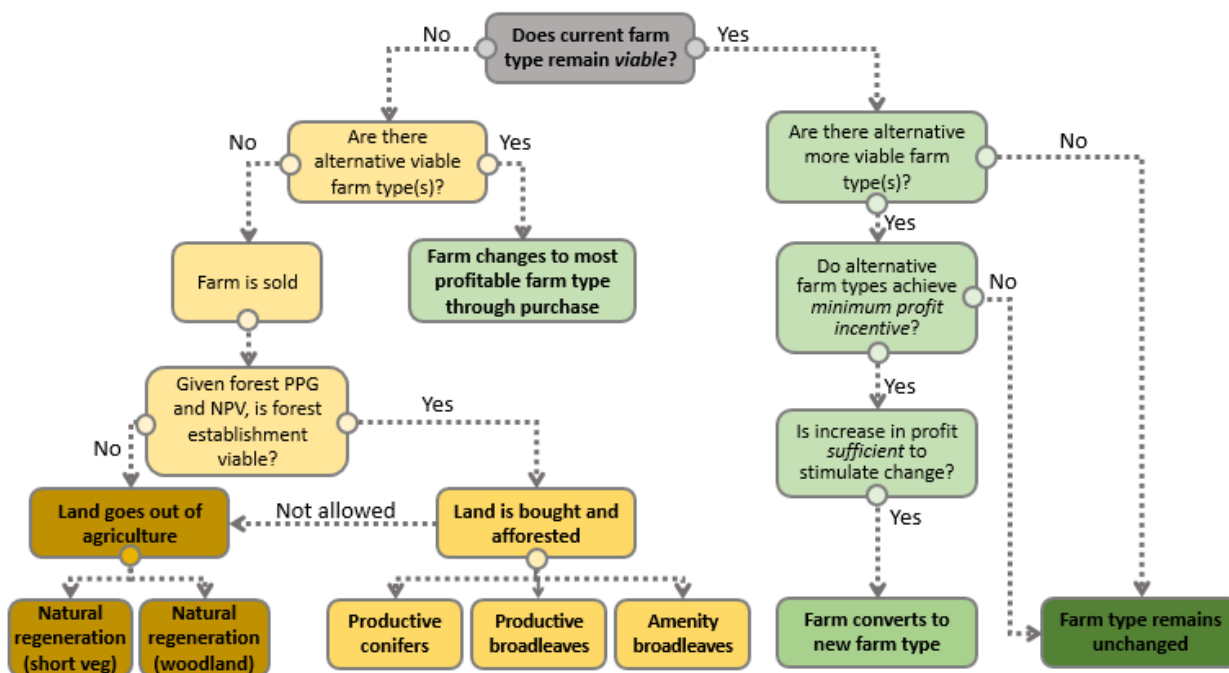
The LAM is a rule-based model, which aims to predict future farm types (and their associated land use and livestock selections) and forest areas across Wales using outputs from the farm and forest models (SFARMOD and ESC-CARBINE). It is applied to all full-time (≥ 1 FTE) holdings across Wales.

The LAM is provided with the optimised SFARMOD farm solutions (crop types / areas, grassland types / areas, stocking types / numbers, fertilisation, etc.) under a given scenario. These include the optimised solution for a holding's current farm type (e.g. dairy), but also for all alternative farm types (e.g. mixed livestock, specialist sheep, etc.). The LAM modifies the simulated long-term net farm profit outputs of each to account for unsimulated income (e.g. non-agricultural sources of farm income and expenditure (unpaid labour, rent and finance, etc.)), using data from each farm type within the Welsh Farm Business Survey.

The LAM then asks four questions for each simulated farm holding under the given scenario settings to determine the projected changes in future land use and management:

1. Is the current farm type, with its cropping / livestock management optimised to the given scenario settings, economically viable in the long-term?
2. Are there alternative farm types that may be sufficiently more profitable to merit conversion?
3. If there are no farm types that are viable with the given scenario setting, is afforestation viable and permitted?
4. If there are no viable farm types and afforestation is not viable or permitted, will land undergo natural regeneration to woodland or short vegetation?

The sensitivity of the LAM to the assumptions regarding economic viability, farm type conversion and unsimulated costs/incomes have been assessed through sensitivity testing and in discussion with a Welsh Government Expert Group.



Schematic representation of decisions and rules within the Land Allocation Module (LAM).

Y Modiwl Dyrannu Tir (MDT)

Mae gan y mwyafrif o'r modelau yn y Llwyfan Modelu Integredig hanes hir o'u defnyddio mewn cyd-destunau amgylcheddol. Yn gyferbyniol, mae'r Modiwl Dyrannu Tir (MDT) wedi'i ddatblygu'n bwrsol gyda Llywodraeth Cymru i adlewyrchu orau penderfyniadau ar ffermydd yng Nghymru. Yn fras, mae'r MDT yn efelychu sut gallai rheolwyr tir ymateb i'r opsiynau amrywiol am ddefnydd tir a rheolaeth tir a ddarperir gan y modelau coedwigaeth ac amaethyddol. Yna mae'n trosglwyddo'r wybodaeth hon i'r modelau bioamrywiaeth a gwasanaethau ecosystem i efelychu canlyniadau'r newidiadau hyn mewn defnydd tir a rheolaeth tir ar yr amgylchedd ehangach.

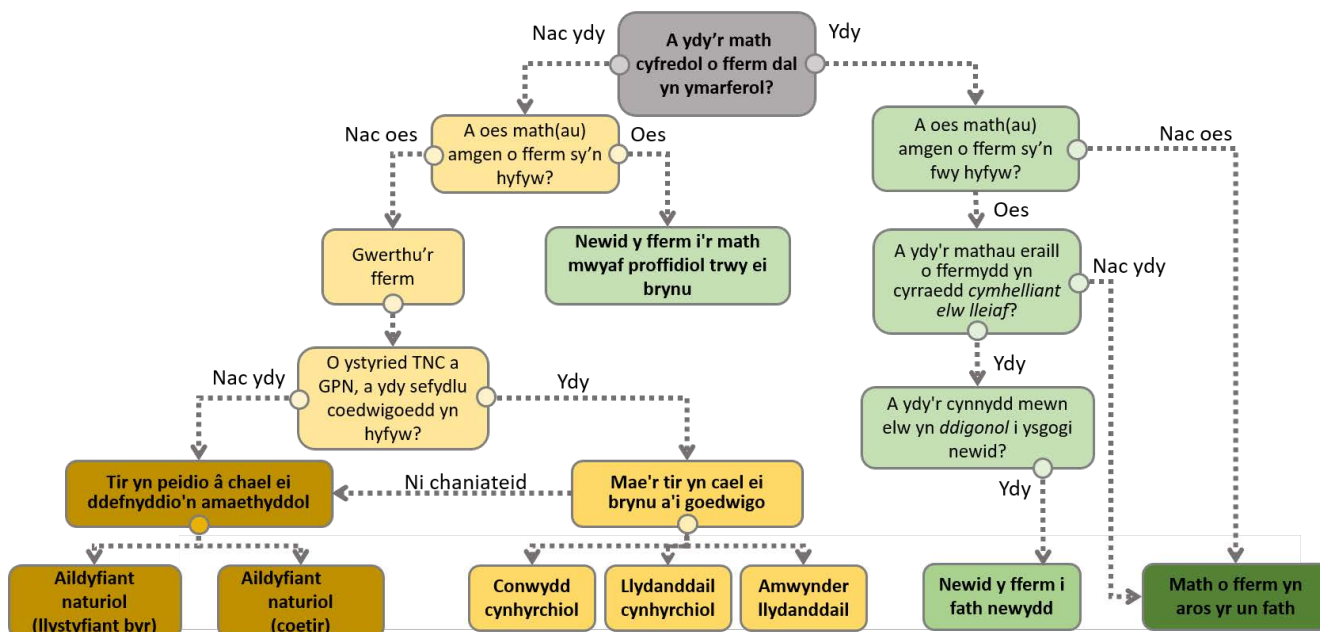
Mae'r MDT yn fodel seiliedig ar reolau sy'n bwriadu rhagfynegi mathau o ffermydd y dyfodol (a'u dewisiadau cysylltiedig o ran defnydd tir a da byw) ac ardaloedd coedwig ledled Cymru gan ddefnyddio allbynnau o'r modelau fferm a choedwig (SFARMOD ac ESC-CARBINE). Mae'n cael ei gymhwyso i bob daliad amser llawn (≥1CALI) ledled Cymru.

Mae'r MDT yn cael ei ddarparu gyda'r atebion fferm SFARMOD optimeiddiedig (mathau / arwynebeddau cnydau, mathau / arwynebeddau glaswelltir, mathau / niferoedd stoc, ffrwythlondeb ac ati) o dan senario penodedig. Mae'r rhain yn cynnwys yr ateb optimeiddiedig am fath presennol fferm daliad (e.e. llaeth), ond hefyd am fathau amgen o fferm (e.e. da byw cymysg, defaid arbenigol, ac yn y blaen). Mae'r MDT yn addasu'r efelychiad o allbynnau elw fferm net hirdymor pob un i gyfrif am incwm sydd heb ei efelychu e.e. ffynonellau an-amaethyddol incwm a gwariant fferm (llafur di-dâl, rhent a chyllid ac ati), gan ddefnyddio data o bob math o fferm o fewn Arolwg Busnesau Fferm Cymru.

Yna mae'r MDT yn gofyn pedwar cwestiwn am bob daliad fferm yr efelychiad o dan osodiadau'r senarios penodedig i bennu'r newidiadau rhagamcanol mewn defnydd a rheolaeth tir y dyfodol:

1. A yw'r math presennol o fferm, gyda'i chnydau / rheolaeth da byw wedi'u hoptimeiddio i osodiadau'r senario penodedig, yn hyfyw yn economaidd yn y tymor hir?
2. A oes mathau amgen o fferm a all fod yn ddigon mwy proffidiol i haeddu trosi?
3. Os nad oes unrhyw fathau o fferm sy'n hyfyw o dan y senario penodedig, a yw coedwigo yn hyfyw ac yn cael ei ganiatáu?
4. Os nad oes unrhyw fathau o fferm hyfyw ac nid yw coedwigo yn hyfyw neu'n cael ei ganiatáu, a fydd y tir yn mynd trwy ailgyfiant naturiol i goetir neu llystyfiant byr?

Mae sensitifrwydd yr MDT i'r rhagdybiaethau ynglŷn â hyfywedd economaidd, trosi math o fferm a chostau/incymau heb eu hefelychu wedi cael eu hasesu trwy brofion sensitifrwydd a thrwy drafodaeth â Grŵp Arbenigol Llywodraeth Cymru.



Cynrychiolaeth amlinellol o benderfyniadau a rheolau o fewn y Modiwl Dyrannu Tir (MDT).

What Do the Models Do and How are They Combined?

Farm Profitability	<p>The whole farm model, SFARMOD, estimates the profitability of various agricultural activities within each full-time farm holding in Wales.</p> <p>To do so, SFARMOD uses input scenario information as well as user-specified management and policy options. These options include agricultural subsidies and rules relating to the area of land under different productive or unproductive management types (e.g. sheep, wheat, fallow, etc.). Given a particular scenario and set of management and policy options, SFARMOD output is an estimate of the profitability of both the current farm type and all potential alternative farm types for each farm holding.</p>
Woodland Productivity	<p>The forestry models, ESC and CARBINE, collectively estimate the productivity and carbon storage potential of forestry, based on the input scenario information and management options. Information on the price of timber as well as the costs of establishing and managing forestry is then used to estimate the profitability of five different forest management options at the scale of a farm holding.</p> <p>These outputs are passed to SFARMOD to allow on-farm woodland to be considered as a potential alternative land use within a farm.</p>
Land Allocation	<p>Profitability of the different farm types is compared within the Land Allocation Module (LAM). Transitions from current land uses are projected through a set of rules and thresholds comparing the current farm type with the most profitable alternative farm type.</p> <p>If the current farm type is viable, the LAM considers whether there is a more profitable alternative farm type. If there is, and the increase in profitability from the new farm type is sufficient to make transition worthwhile (given the capital investment needed to transition) the modelled farm will change land use to the more profitable farm type; if not, farm land use will not change.</p> <p>If the current farm type is <i>not</i> viable, the modelled farm will be projected to change to the most profitable viable farm type. If no viable farm type is available, the LAM will consider whether forestry is a profitable alternative instead. If so, forestry will be established, and if not, the modelled land will be considered to be go through natural succession in the modelled outputs.</p>
Agricultural Emissions	<p>Once the predicted land allocation is established for each farm, the agricultural emissions model, FARMSCOPER, determines the emissions from each modelled farm based on their size and typology. Emissions include nutrients (e.g. P), greenhouse gasses (e.g. CO₂) and pollutants (e.g. NH₃-N), and may be affected by user specified mitigation measures.</p>
Ecosystem Services	<p>The Ecosystem Service (ES) models use the information from the LAM on changes in on-farm land use and management to estimate changes in carbon sequestration due to land use, land use change and forestry (LULUCF) and changes in peatland use. This information is combined with the information from FARMSCOPER on greenhouse gas emissions from agriculture to estimate overall changes in carbon. The ES models also use information passed from FARMSCOPER to assess changes in water quality (e.g. Water framework Directive P status, drinking water N status, sediment loss from agriculture).</p>
Biodiversity	<p>Habitat suitability for plant and bird species is simulated using the MULTIMOVE and BTO models using information on on-farm land use and land management from the LAM.</p> <p>MULTIMOVE estimates habitat suitability for a wide variety of plant species, including woodland and arable specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats, e.g. lowland grassland, lowland wetlands, lowland heath and upland habitats).</p> <p>Bird population models developed by the British Trust for Ornithology are used to predict species-specific abundance for 68 bird species associated with different habitats across Wales. In addition, the broadleaf woodland connectivity model estimates the effect of new on-farm woodland and afforestation (as passed from the LAM) on connectivity between existing woodland patches.</p>
Air Quality and Human Health	<p>The EMEP4UK meta-model uses information passed from the LAM on new woodland and information passed from FARMSCOPER on ammonia emissions from farms to estimate changes in fine particulate matter (PM_{2.5}) concentration. Implications of these changes for human health, in terms of life years lost, are then computed.</p>
Valuation	<p>In the final stage of the IMP integrated chain, ecosystem services/public goods are valued using monetary values for carbon, water quality and the health impacts of air pollution. ES valuation follows a hierarchy of valuation methods (market prices, avoided costs, revealed preference and stated preference) using value transfer approaches and following best-practice guidelines. The monetary values are presented alongside physical values for all indicators, including biodiversity, and effects on farm business income.</p>

Beth Mae'r Modelau yn eu Gwneud a Sut Fyddan Nhw'n Cael eu Cyfuno?

Proffidioldeb Fferm	<p>Mae model fferm gyfan, SFARMOD, yn amcangyfrif proffidioldeb amrywiol gweithgareddau amaethyddol o fewn pob daliad fferm amser-llawn yng Nghymru.</p> <p>I wneud hynny, mae SFARMOD yn defnyddio gwybodaeth senario a fewnbynnir yn ogystal ag opsiynau rheoli a pholisi sy'n cael eu pennu gan y defnyddiwr. Mae'r opsiynau hyn yn cynnwys cymorthdaliadau amaethyddol a rheolau mewn perthynas â'r arwynebedd tir o dan wahanol fathau o reolaeth gynhyrchiol neu anghynhyrchiol (e.e. defaid, gwenith, braenar ac ati). Drwy roi senario penodol a set o opsiynau rheolaeth a pholisi, mae allbwn SFARMOD yn amcangyfrif o broffidioldeb y math presennol o fferm a phob math amgen posibl o fferm am bob daliad fferm.</p>
Cynhyrchedd Coetir	<p>Mae'r modelau coedwigaeth, DSE a CARBINE, gyda'i gilydd yn amcangyfrif cynhyrchedd coedwigaeth a'i photensial i storio carbon, ar sail yr wybodaeth senario a fewnbynnir ac opsiynau rheoli. Yna defnyddir gwybodaeth am bris pren yn ogystal â chostau sefydlu a rheoli coedwigaeth i amcangyfrif proffidioldeb pum opsiwn gwahanol rheoli coedwig ar raddfa daliad fferm.</p> <p>Trosgrwyddir yr allbynnau hyn i SFARMOD i ganiatáu i goetir ar-fferm gael ei ystyried yn ddewis amgen posibl am ddefnydd tir o fewn fferm.</p>
Dyraniad Tir	<p>Cymerir proffidioldeb y gwahanol fathau o fferm o fewn y Modiwl Dyrannu Tir (MDT). Mae trosiannau o ddefnyddiau tir presennol yn cael eu rhagamcanu trwy set o reolau a throthwyon sy'n cyharu'r math presennol o fferm â'r math amgen mwyaf proffidiol o fferm.</p> <p>Os yw'r math presennol o fferm yn hyfyw, mae'r MDT yn ystyried a oes math amgen o fferm fwy proffidiol. Os oes, ac mae'r cynnydd mewn proffidioldeb o'r math newydd o fferm yn ddigon i wneud trosi'n werth chweil (yng ngoleuni'r buddsoddiad cyfalaf mae ei angen i drosi) bydd fferm y model yn newid defnydd tir i'r math o fferm fwy proffidiol; os nad yw, ni fydd defnydd tir y fferm yn newid. Os <i>nad</i> yw'r math presennol o fferm yn hyfyw, bydd fferm y model yn cael ei rhagamcanu i newid i'r math o fferm hyfyw fwyaf proffidiol. Os na fydd unrhyw fath o fferm hyfyw ar gael, bydd yr MDT yn ystyried a yw coedwigaeth yn ddewis amgen proffidiol yn lle. Os felly, bydd coedwigaeth yn cael ei sefydlu, ac os na, bydd tir y model yn cael ei ystyried ar gyfer mynd trwy'r olyniaeth naturiol yn allbynnau'r model.</p>
Allyriadau Amaethyddol	<p>Ar ôl i'r dyraniad tir a rhagfynegir gael ei sefydlu am bob fferm, mae'r model allyriadau amaethyddol, FARMSCOPER, yn pennu'r allyriadau o bob fferm y model ar sail eu maint a'u typoleg. Mae allyriadau'n cynnwys maethynnau (e.e. P), nwyon tŷ gwydr (e.e. CO₂) a llygryddion (e.e. NH₃-N), a gall mesurau lliniaru a bennir gan y defnyddiwr effeithio arnynt.</p>
Gwasanaethau Ecosystem	<p>Mae'r modelau Gwasanaethau Ecosystem (GE) yn defnyddio'r wybodaeth o'r MDT am newidiadau yn nefnydd tir a rheolaeth ar-fferm i amcangyfrif newidiadau mewn atafaelu carbon o ganlyniad i ddefnydd tir, newid defnydd tir a choedwigaeth (DTNDTCh) a newidiadau yn nefnydd mawndir. Cyfunir yr wybodaeth hon â'r wybodaeth o FARMSCOPER am allyriadau nwyon tŷ gwydr o amaethyddiaeth i amcangyfrif newidiadau cyffredinol mewn carbon. Mae'r modelau GE yn defnyddio gwybodaeth a drosglwyddir o FARMSCOPER i asesu newidiadau mewn ansawdd dŵr hefyd (e.e. statws P y Gyfarwydddeb Fframwaith Dŵr, statws N dŵr yfed, colled gwaddodion o amaethyddiaeth).</p>
Bioamrywiaeth	<p>Efelychir addasrwydd cynefinoedd am rywogaethau planhigion ac adar gan ddefnyddio modelau MULTIMOVE a YAB sy'n defnyddio gwybodaeth am ddefnydd tir a rheolaeth tir ar-fferm o'r MDT. Mae MULTIMOVE yn amcangyfrif addasrwydd cynefinoedd am amrywiaeth eang o rywogaethau planhigion, gan gynnwys rhywogaethau planhigion arbenigol coetir a thir â'r rhywogaethau positif Monitro Safonau Cyffredin (MSC) (planhigion arbenigol cynefinoedd lled-naturiol eraill, e.e. glaswelltir iseldir, gwlyptiroedd iseldir, rhos iseldir a chynefinoedd ucheldir).</p> <p>Defnyddir modelau poblogaethau adar a ddatblygwyd gan Ymddiriedolaeth Adareg Brydeinig i ragfynegi helaethrwydd rhywogaethau penodol ar gyfer 68 o rywogaethau adar sy'n gysylltiedig â chynefinoedd gwahanol ledled Cymru.</p> <p>Yn ogystal, mae'r model cysylltedd coetir llydanddail yn amcangyfrif effaith coetir a choedwigo newydd ar-fferm (a drosglwyddir o'r MDT) ar gysylltedd rhwng ardaloedd coetir presennol.</p>
Ansawdd Aer ac Iechyd Dynol	<p>Mae meta-model EMEP4UK yn defnyddio gwybodaeth sy'n cael ei throsglwyddo o'r MDT am goetir newydd a gwybodaeth sy'n cael ei throsglwyddo o FARMSCOPER am allyriadau amonia o ffermydd i amcangyfrif newidiadau yn y crynodiad mân ddeunydd gronynnol (PM_{2.5}). Yna cyfrifir goblygiadau'r newidiadau hyn i iechyd dynol, yn nhermau blynyddoedd bywyd a gollir.</p>
Prisio	<p>Yng ngam olaf cadwyn integredig yr IMP, mae gwasanaethau ecosystem/ nwyddau cyhoeddus yn cael eu prisio gan ddefnyddio gwerthoedd ariannol am garbon, ansawdd dŵr ac effeithiau iechyd llygredd aer. Mae prisio GE yn dilyn hierarchaeth dulliau prisio (prisiau marchnad, costau a osgoir, ffafriaeth a ddatgelir a ffafriaeth a ddatgenir) gan ddefnyddio dulliau trosglwyddo gwerthoedd a dilyn canllawiau arfer gorau.</p> <p>Mae'r gwerthoedd ariannol yn cael eu cyflwyno ochr yn ochr â gwerthoedd ffisegol am bob dangosydd, gan gynnwys bioamrywiaeth, ac effeithiau ar incwm busnes fferm.</p>

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Ymhelaethir ar fyfoddau a rhai o'r termau technegol a ddefnyddir yn yr adroddiad hwn yng ngeirfaedd y rhaglen/
Abbreviations and some of the technical terms used in this report are expanded on in the programme glossaries:
<https://erammp.wales/en/glossary> (English) & <https://erammp.cymru/geirfa> (Cymraeg)

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