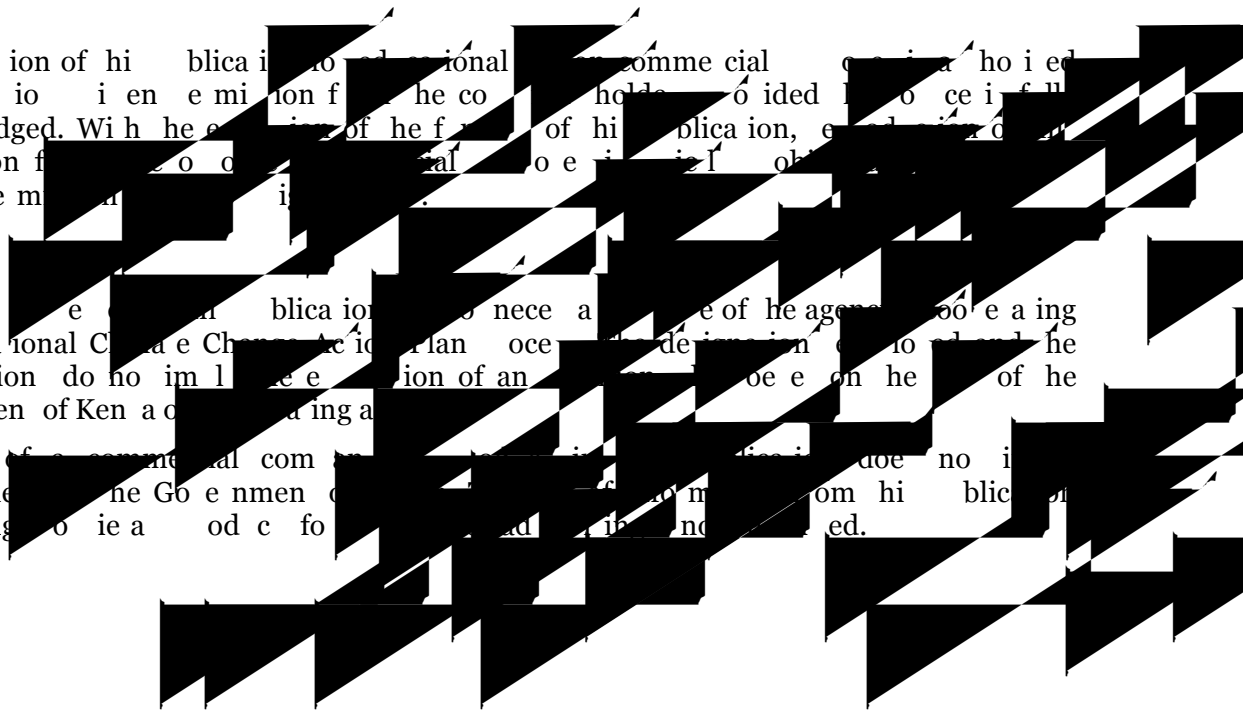
ECN

ASB Partnership for the Tropical Forest Margins

[redacted]



IISD i a Canadian-ba ed, blic olic e ea ch in i e ha eciali e in olic e ea ch, anal i and info ma ion e change. The in i e cham ion ainab de elo men h o gh inno a ion, and ela ion hi ha an he en o l

ECN de elo high- ali o le a echnolog fo he an i ion o ainable ene g managemen . ECN in od c i kno ledge and echno e ma ke . ECN foc i on ene n e a ion, ainable ene g and an efficien and clean e of fo il f el .

Debo ah M h , Se on S iebe ,
Da e Sa e , Ja on Dion, Sco McFa idge, In e na ional In i e fo S ainable De elo

La a W enbe ge , La an Came on, Rao f Saidi, Xande a Tilb g, Ene g Re ea ch Cen e he Ne he land

Pe e A. Minang, ASB Pa ne hi f he T o ical Fo e Ma gin a he Wo ld Ag ofo e Cen e

Tom O ino, Clim

Pe e on Ol m

ASB i he onl global a ne hi de o ed en i el o e ea ch on he o ical fo e ma gin . ASB aim o ai e od c i i and income of al ho ehold in o ic i ho inc ea ing defo nde mining e en ial en i on al e ice .

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Thi doc men i an o f om a ojec f nded b he UK D men fo In e na ional men (DFID) and he Ne he land Di ec o a e-Gene al fo In e na ional a ion (DGIS) fo he of de elo ing co n ie . Ho e e , he ie e ed and inf a ion co ned in i a e no nece a no e of o endo ed b DFID, DGIS o he en i ie ma f he Clima e and men hich can acce no e on ibili , com le ene ac of he ma ion o an eliance laced on hem.

2012, A e e ed

* The Clima e and De men Kno ledge Ne CDKN) i a ojec f nded b he UK D men fo In e na ional De elo men (DFID) and he N land Di ec o a e-Gene al fo In Coo e a ion (DGIS) and i led and admini e ed b P ice a eCoo e LLP. Managemen of of CDKN i nde aken b P ice a e ho eCoo e LLP, and an alliance of o gani a ion ing F F o La inoame icano, INTRAC, LEAD In e na ional, he O e ea De elo men In i e So h No h.

BAU	b ine a al
CDM	Clean De elo men Mechani m
CO_2	ca bon dio ide
CO_2e	ca bon dio ide e i ale
GHG	g eenho e ga
IPCC	In e go e nmen al Panel on Clima e Change
MSW	m nici al olid a e
M	million onne
MW	mega a
NAMA	na ionall a o e mi iga ion ac ion
NEMA	Na ional En i onmen Managemen A
REDD+	ed cing emi ion f on and fo e deg ada ion l he ole of con e a ion, ain gemen of fo e and enhancemen of fo e ca bon ock
UNEP	Uni ed Na ion En i onmen P og amme
UNFCCC	Uni ed Na ion F ame o k Con en ion on Clima e Change
UNICEF	The Uni ed Na ion Child en F nd

Thi cha e i a of a la ge anal of l ca bon de elo men o ion in Ken a, l
co e he i mi iga ion ec o e o in A icle 4.1 of he Uni ed Na ion F am
Con en ion on Clima e Change (UNFCC : ene g , an o , ind , a e, fo e and
ag ic l e. The ho inal i ion o info m he Ken a Cl ion
Plan and o ide e ce ba ing lo -ca bon de n and
de elo ing o o a fo na ional A a e Mi iga ion Ac io) and REDD+
ac ion .

The anal i in g e emi ion in en nd
efe ence ca e emi ion 20 en i e Ken an econom and h
ec o . The anal h ion a e ho lo -c men o ion can bend do
emi ion f om he o o ed e ec o . Recogni ing Ken a
de elo men io i ie an al o con he a io o ion an
con ib e o ainable ken . The o e k co de i h of
io i ac ion o enable l en .

Thi cha e ana on he en a and i
one of e cha e de elo e h bo cena io anal i .

Ken a i e e iencing a id g o h gene a ion olid a e. In Na obi, fo e am le,
m nici al olid a e (MSW) ol a e edic ed o g o f om 2,000 on a da
in 2009 o 5,400 on a da in 202 o ia em fo a on, managemen
and di o al a e a co en a he ignifican l ib e o cleanline
and heal h in h lemen d a all and di o al ha
im o ed o e h ea ill o e a co ding o he Ken a
Na ional En i on, nagemen A ho i (N 4 en of a e gene a ed
in ban cen e i ec ed di o ed of de ed di e .[2]

Mo of he ed a e i bi i an o Da do a, he ci ficial e
di o al i e. ando a, one o ica la ge o I o ie , i an ndfill[3]
i ho con ainmen echnolog , hich lead lace a e and g e ll ion,
and nega i e im ac on h of nea b en , e ec d en Simil a ion
can be ob e malle cale in ban cen e co al a ea , a e
i mainl b di o ed of in an n la ed f ion.

The o i ion of ade a e acili ie in an a ea age di o al, o
ano he challenge. A g o i o la ion lead o inc ea e a e n of a e a
need o be managed. Sho a i a e in ome a of he co n ain ed
fo ade a e of a e . A 20 lica f he Wo ld ani a io
and UNICEF ha acce o ani been im e a 2
ea in Ken a and 32 e cen of he o h acce o im i a ion fa
in 2010.[5] Ho e e , onl an e ima ed e cen h e age co e,
and a a na ional le el a fi e e cen ea ed.[6]

Bo h a e di o al and age he f a ec i e,
beca e me hane i gene a ed in e a in a landfill,
ch a food e id e , a e and , i dec ed b mi hich g e a e a
mi e of me hane, ca bo CO_2) and ace o he . Thi ga eo mi e
called landfill ga , hich eciall d lan ha e a la g
den i of di o ed a e ha c hae condi ion hich me hane

od ced. Me hane i a o g eenho e ga ha a global a ming o en ial of 25 ime ha of CO_2.[8] When fo lo ing In e go e nmen al Panel on Clima e Change (IPCC) le fo calc la ing GHG emi on in an econom in a e ec o (hich incl de ea men) e emi ion f o a e di o al on land gene all e en main o GHG emi ion in h o .

In a a e a e ea men lan , m i gene a ed o gani m in he a e a e i decom o ed nde anae obic co ion b me hane-fo ming gani m . Me han emi ion f om a e a e ea men lan a g ne all co ed o be he econ la ge o ce of GHG emi io n h ec o acco ding o IPCC in en o le .[9]

Va io go e nmen mini ie and agencie , a e i a e ec o la e , a e in ed in he a e and a e a e en ec o in K a. On he na ional le el, he o e all olic -making e on ibili e i h he Mi of En i onmen and Na Re o ce (MEMR) fo a e, and Mini f P blic Heal h and Sani a io a ic A i e on ible fo he o e nfo men of e ali and a e a ion .

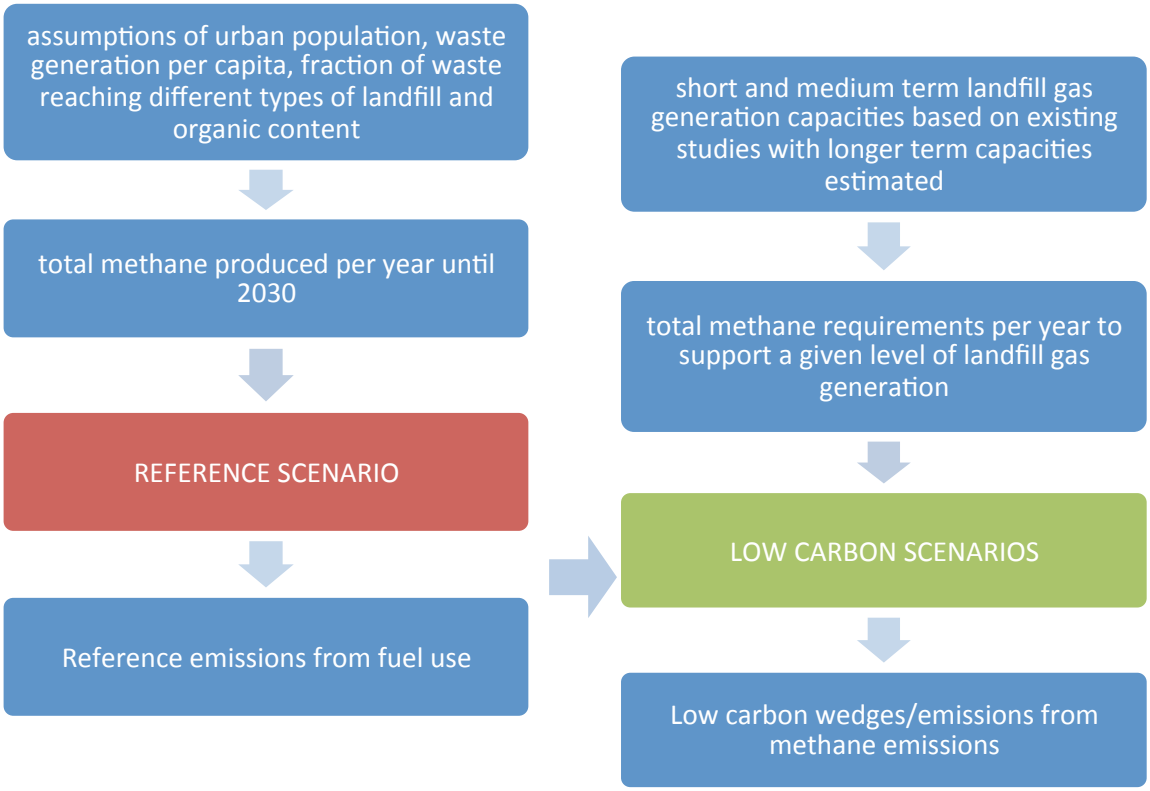
The ima on ibili fo ac ical lemen a ion of e colle , di o al and manageme and age em lie i h Ci Co ncil . The e e on ibili ie ma change i e, nde Ke a ne con i on he c en em of local go e nance i ed a e co n ec ed o c ea e ne local go e nance e .[10]

The Ken a In e men A Ci Co ncil in e aging a ec a ici a ion in he a e e .[11]

The a e la ed a he na ional le he En i onmen al Managemen d Co-o dina (W e Mana) Reg la ion of 2006[12] Ci le el lanning men la a cen al ole in lanning and im lemen a of a e an é managemen em . The Ci of Nai obi, i h o of Uni ed Na ion E nmen P og amme (UNEP), ha en o king on an In eg a ed a e Manageme Plan

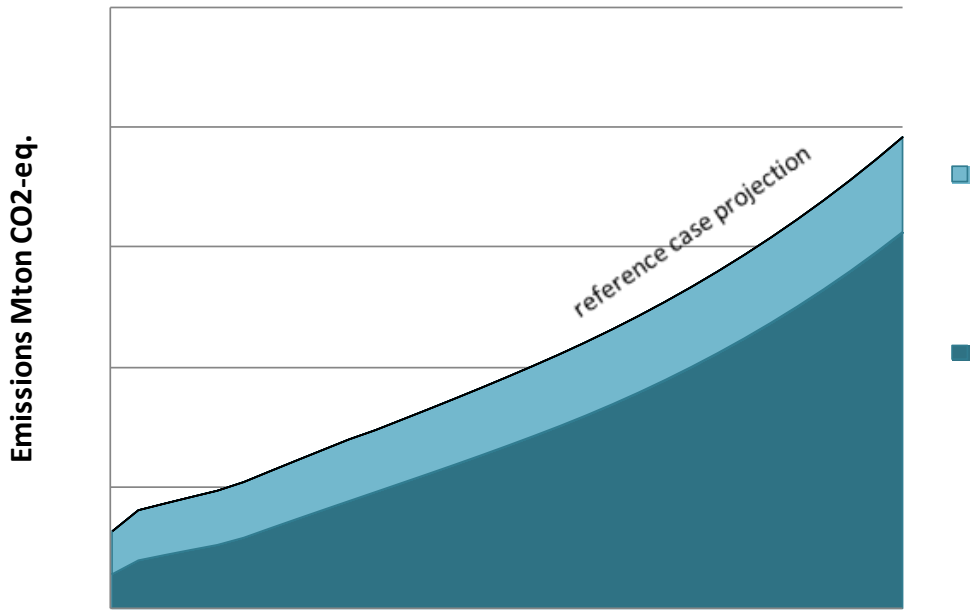
The e i li o e e ience i h lo -ca hi ca gie in he a e o i hin he c en eg la and olic f a e on ion of ch echnologie e i e con ide a ion of ho e manage he h o collec and ili e ga f om landfill o a e a e .

Wa e managemen and e an ion of e ag a e im o ed in Ken a, e he o i ion of com ehen i ge of ill o e a challenge. The e a o o ni ie o im o e: he cc ion of a ac ion of a e ha eache ma landfill , landfill manag en and a n ac ice . Mo ing i on o ld allo lem



Unce ain ie in e ima e of e a e mi ion a e ima il ela ed o he m od c ion ca aci and he logical O gen Demand e e on ha can bo h e 30 e cen .[16] The emi ion ba ine e en ed an ifie me ha emi ion f m man a e . E ima e of me ne gene a f om ind ial a e a e ni ide emi ion e a o incl ded in hi anal i b o incl ded in Ken a n nica ion in en o e a in info ma ion o gene a e a e e.[17]

The emi ion ba eline fo he éc o i mma i ed in Fig e 9.2. To al emi ion a e e ec ed o g o f om 0.8 m n onne (M) in 2010 M in 2030 e an ann al g o h a e of 4.9 Solid a e di o emi ion a e i ing e han o la ion g o h beca lag ime in emi ion elea e of a e ha ha e been de o i ed in Solid a di o al er ion o n fo o ima e cen a e ec o ion f 2010 o e iod.



The lo -ca bon cena io anal i con i ed of iden if ing lo bon de elo men o ion , and calc la ing he mi iga ion o en ial again he efe ca e. The ing edge anal i demon a e he emi ion ed c ion o en ial b lo -ca bon e olog in he ec o .

The iden ifica ion of lo -ca bo f he anal a ici a o e a oach ha i de c ibed e 1. Fe ible o ion iden ified in he e ec o and one o ion a ed: Lan m ane ca elec ici gene a ion). Thi o ion an e l e e alida i 2012 fo e i f om Ken 9.1 di c gge ed b e a ion fo cl ding in h -ca bo .

The aba emen o en ial of hi o c la ed in o he efe enc e, ing he ame bo om- a m on on he ol MS collec ed, he e cen age of a e ha eache landfill ha co ld b i able fo me h collec ion and ili a ion,[18] a ell a he o ganic con en a la eg e mine he me hane od c ion o en ial). Th ing ia ing he ed c ion in me ha emi ion d e o landfill ga collec i d c ion (in hi ca ning fo elec ic gene a ion) i a 2010 of bioga en ial in Ken a.[1] Th con ide e ima e of (and co en ial de ending on fe ble co le el . I al o ide ia e of he o ane e ed fo hi gene a ion.

Wa e echnologie o o ed a local alida ion g b e cl ded af e f he anal i a e de c ibed belo .

i e he landfill me hane ca e o ion, b he ca ed me hane i im l oid i elea o he hé e. I i a econd-be o ion beca e no elec i od ced and on ic ed f he in he lo -ca bon cena io. I mi iga ion o ial o ld be imila a calc la ed fo landfill ga mode n high fl echnol ed; i n olde dle fla e o 1 o me hane ma a ed n-b n.

i a o fea e ol ion a co ld be con ide ed anal i . A 2010 d on ag ial a e a e ge ha he o en ial fo ca e and ili a ion i el el lo beca e he hane o en ial e c bi e a e a e a e m ch lo e han olid e o he lo con en in o ganic ma e ial and high a e con en .[20]

i of en be e i ed o a ea i h a o landfill (beca e of he lo e co of ing landfill) and a e i h a lo e e ighe ene g con en (le likel in Ken a beca e o high o ganic a e con en).[21] Al ho gh incine a ion can ill o e benefici de he ndi ion , he e i a ignifican o e la i he o ion of elec ici g f om landfill ga i ho a o ia e a e e a a io ac ice , hich a e no c fo nd in Ke .

n o o- age oce of anae obic dige i ng. I can ea e o ec e ene g in he fo m of bioga , and com m of li id e i n o ld ed ce me hane emi ion and ma od ione . addi ion, bioga can gene a e elec ia ga engine need a feed eam of o ce- e a a ed o ganic a e , in he fo m of an e (hich i collec ed in Ken a) o m nici al o ganic a e (hich a collec e al e id e a e con ide ed a a coge ion o ion in Cha e 8 nd i .

The e fig e o ide a a ing oin fo e a med land ga gene a ion o en ial in he lo -ca bon cena io in he ho and medi m e m To al in alled ca aci ie a e con e a i el a med in he mo e d an f (202 nd 2030) ba ed on a mode a e inc ea e in he e cen a e ha ed and di o ed of in a managed landfill . The m ane e i eme o o hi le el of gene a io e in a e hen e ima ed and d d c ed f om o ken an me hane emi ion f om MSW in a gi ea .

I ho ld al o be no ed ha addi ion me hane, he decom of o ic ma e ial MSW od ce CO_2. The me hane od ced and elea ed o mo he e con ib e o global a ming and he emi i need o be e ima ed and e o ed. Ho e e , b CO_2 od ced o igina e f om bi e o ce (ch a food, ga n, a e a a e) and h he emi ion o be con ide ed in n en o ie .[22]

Finall , o iga ion o en ial of a me h e i calc la ed ced elec ici ion o en ial (a e l of le co nd die el e

Wi h ega d o da a a ailabili f mi ion ó ion , he i a ion i im o he da a oblem e e ienced in e hing h a e ec o ba eline.

Limi ed eliable da a i a landfill ga gene a ion e , he main o ce a a a 201 ha ed on Nai obi.[25] The e e ef l o ce of e ima ac o he of he c . I a a med ha he cha ac e i ic of a gemen and landfi ed in Nai obi co ld be e (ba ed on o la ion n mbe) in he ce of ecific da a.

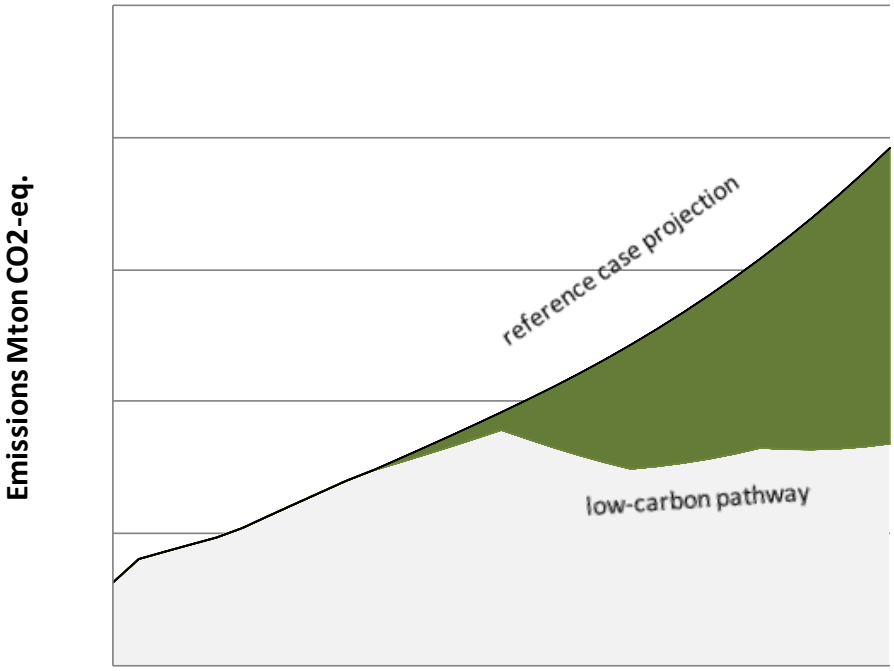
Landfill ga me hane ca lec ici gene a n) i he one -ca bon de elo men o ion anal ed in he ec o . MSW c ea ed b a la ion i a ignifican managemen oblem fo an co n f and economic ec i e F om a clima e change ec i ane i a he o ganic c in MS lo l deg obicall (ho e o o gen). The deg hi occ i de en di ion in h e e he MSW i di

Al ho gh me hane i a gh global en lar and con ib e o clima e change, i i al o a ce of ene g i be ca ed. Thi and e of me hane f om MSW lec ici i d in man co n ie , de and de elo ing, ac o he o , b ld be a ne chnolog fo Ken a he la ge landfill i e in Ken a, ha been n ce f l a em landfill ga gene a ion oject and al en co de ed a a o en ial CDM

A ecen d b Ge n e na ional 5 432.062 (co (m) -7 (a(a) -5 0.24 0 0 0.24 4

alone, ba ed on 2009 a e le el .[31] The lo -ca bon [illegible] me a mean al e of 37.5 MW can be eali ically de lo ed in 2020 and he ma [illegible] m al e of 64 MW in 2025. Fo 2030 i i a med ha [illegible] ma im m MSW me hane o en ial in Nai obi ha a o ima el do bled (co [illegible] he hole of Ke [illegible]). The final ca aci ie of landfill ga gene a ion can be een in he fac hee [illegible] 1.

Fig e 9.3 onl con ide [illegible] ion o en ial f om me hane e [illegible] ion a oidance (a o ima el 1.1 kilo onne [illegible]e in 2030). An mi [illegible] o en ial f om di laced elec ici i calc la ed in Ch [illegible] e 5, Elec ici Gene a i [illegible] The [illegible] n ial f om me hane emi ion a oidance i f [illegible] ó ghl ice a [illegible] e o en ial f om elec ici di lacemen



The co a e e o ed a ma ginal aba eme co [illegible] he ame a ho e e en ed in he elec ici ec o cha e . The e a e [illegible] ed [illegible] US$ -4.90 e CO_2 in 2020 and US$ -12.40 e CO_2 in 2030. The ch [illegible] e o e ime i d e o diffe en a m ion in lea ning a e be een la [illegible] gene a ion [illegible] d con en ional gene a ion echnologi again hich he a io [illegible] abl [illegible] echnologie a e com a ed.

- Im o emen of local ai and e (f emi ion of l h o ide, ni ogen o ide and a ic la e) h o gh b n ie coal fo elec ici gene a ion and ed c ion of landfill ga el ed in o he ai .
- Red ced i k ga concen a ion in landfill ar ced e o e of den ia .
- Small inc ea e in local em men .
- In ome ca ional b he oje c o o og amme akeholde incl fo ing nea he i and ho a e affec ed b he oje c.[3]

The oce of de ig ing and o landfill g job , ho e e he e ed and local c ne local economic im a

Landfill ga me hane ca ide and ge, e ili ha e ange beca e i o ld e e ience e m im ac a i on an al e of e ing elec ici f om h d o o e . Wa e h and a ma ha e a mal ac on me h od c ion a e , ho e e n abo he ec and ndfill condi ion Ken a o a an hing e.

The fea ib of landfill ga ca e and e in Ken a i lim ed b he f o ing ba ie :

- Lack of legi la ion: C en l no eg la ion enfo cing landfill ga e ac ion i h o i ho ili a ion.
- Unfa o able financial e . The financia e fo mance of é al CD oje c in he field of lan ga ca e and e i of en in lien o a ac eno gh in e men f nding f om financi e (beca e h i na ac i e com a ed he in e ded b local he ca e of he CDM, e financiall ed h o ale of c edi ba ed on he a o ce of me hane emi ion .
- Wa e managemen a lable ac o and i hin ci ie . S a ea a e m ch be e d e o financial a con ain) han o h
- A lack of echnolog amilia i ene , a ell a and lack of a ailab i of e i men .
- Po en iall a lack of ocial acc ance. Fo e am ce of l hood fo a man a le. Thi de e mining he cce of a e oje c .
- T e of landfill a ke ba ie W ha en l eache dee e landfill (fo e an IPCC de e han fi 5 me e o he e he e i a high a e Da in Nai obi i of hi e). Onl abo 18 e cen of an MS e en he hi e of landfill. To im gene a ion ial o o d o he ca aci ie ha a d) need o inc ea e hing like 50 e cen b 203 ho ld be i h he de e men goal he go e he inc ea e a m

The e idence gge ha fa o able olicie can be a ignific effec on landfill ga ili a ion and co e onding GHG mi iga ion.[37] d i e behind landfill ca e (and b e en elec ici gene a ion) in de elo ed co n ie eg ion. In de elo ing co n ie , he deci ion o ca e and e land g e all financiall mo i a ed.[38]

The e incen i e ha e of en bee gh he ale CDM. Mo e han 75 ojec a e of landfill ga fo fla g o elec ici gene a ion. Ho e e , in i go e nmen i he o enco age dome ic ac ion inde enden l of he DM, local gene a ion incen i e ed, ch a feed-

When solid municipal waste (MSW) is dumped in landfills, the organic component can degrade in the absence of oxygen; this is called anaerobic digestion. This process releases methane that typically escapes to the atmosphere and contributes to climate change. The methane can be captured (and can be used as a source of fuel to generate electricity and heat through combustion; see option for electricity generation from landfill gas in Chapter 5, Electricity Generation). In the waste sector, only the mitigation potential of avoided methane is calculated. The displaced electricity mitigation potential (because less coal and diesel is used) is shown as an electricity wedge in Chapter 5. The mitigation potential is split between the waste and electricity generation sectors. The marginal abatement cost, is however calculated using the total potential summed together.

Current situation: Feasibility study for the use of landfill gas (from MSW) in Nairobi, but no concrete plans for implementation. Initial studies suggest up to 64MW of generation capacity in Nairobi is feasible.[40]

Low carbon scenario: Moderate growth such that the existing capacity in Nairobi is exploited in 2020, growing to 100 MW across all of Kenya in 2030.

Development benefits and priorities

Development benefits:

- Improved management of landfill.
- Potential source of baseload electricity for reliable power supply.
- Significant additional GHG benefits from avoided emissions from alternate fossil fuel generation in the electricity generation sector. The abatement potential shown here for the waste sector only shows the reduction in methane.
-

Scenario	2010	2015	2020	2025	2030
Methane used for generation - low carbon scenario (mil. m^3)	-	4.5	31.2	47.6	74.5
Abatement potential ($ktCO_2e$)	-	67	46	714	1,116

Feasibility of implementation

A key barrier is the amount of MSW that currently reaches deeper landfill, which is defined by the IPCC as 5m or where there is a high water table. Dandora landfill in Nairobi is this type. Currently about 18 of total urban MSW in Kenya reaches this type of landfill. This needs to increase to approximately 50 by 2030 to improve generation potential out to 2030 and support the capacities that are shown here. This increase is likely to be aligned with the development goals of the government, and therefore is a valid assumption. Moreover, any investment related to official landfills in Kenya will require the approval of the respective city council.

[1] Von Blo ni , H. 2011. *I eg a ed S id Wa e Ma age e P a f he Ci f Nai bi, Ke a.* De elo ed fo he Ci Co ncil of N obi on A ignmen o he Uni ed Na ion En i onmen P og amme (UNEP). 1 D af , a ed a : h :// . ne .o .j /ie c/G M/da a/T 4_Nai obi_ISWM_lan_d af 1_19Feb. df.

[2] NEMA. 2012. *W age Ke a.* Web i e. Acc e 2012 a : h :// .nema.go.ke/in ?o i ce con en & cle&id=311: a e-manage a - in-ken a&ca em .

[3] Landfill a e a e de o i o ie n b a go. e m agenc ha ho ld ad éle an a e ea men la and oce ing eg la ion . D n a e info mal, o illegal, i io he di o al of a e and a e n eg la ed.

[4] Wo ld Bank. 2011. *Nai bi Me ice P jec P jec I f a i D c e , C ce S age.*

[5] Wo ld Heal h O gani a ion a NICEF. 2012. *E i a é ne e f i ed a i a i faci i ie Ke a.* U da ed M 2012. Acce e : h :// . info.o g/filead / e _ load/ e o ce /KEN_ an.

[6] Gak bia, R., Poko ki, U., and On ango, P o. U caling Acce o S ainab ani a ion. P e en a ion a he *F* *he I e a i a Yea f Sa i a i (IYS)*, 26 h Jan a , Tok o, Ja an. Acce ed a : h :// . io m.j /en /agenda/doc/ e 12_D .Ul ikePoko ki.

[7] UNEP. 2010. *Wa e a d C i a ge - C T d a d eg E e* . Acce ed a : h :// . ne .o i /ie c a ion / e&Clima eChange/ e&Clima eChange. df

[8] A ming a ime ho i of 100 ea in acco dance i h IPCC 2007 le .

[9] UNEP. 2010.

[10] Wo ld Bank. 2011.

[11] See fo e am le: h :// n e ken a.c men _o o ni ie /225060.h m.

[12] A ailable a : h :// . ne .o g/ ban e onmen / /ISWM2_Wa eManagemen Reg la ion .

[13] on Blo ni , H. 2011.

[14] Go e nmen of Ken a. 2007. *Ke a Vi i 2030: A G ba C e i i e a d P e Ke a.* Nai obi: Go e nmen of Ken a.

[15] In e go e nmen al Panel on Clima e Change (IPCC). 2006. *2006 IPCC G ide i e f Na i a G ee h e Ga I e ie* . Ha ama: In i e fo Global En i onmen al S a egie on behalf of he IPCC.

[16] IPCC. 2006.

[17] MoE 2012. *Na i a E e g P ic hi d d af* . Nai obi: MoE.

[18] In hi ca e ba ed on he IPCC landfill ca ego i a ion ane i con ide ed f om MSW landfill of g ea e han fi e me e de h o i h high a e le el

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[40] Fi che e a 0.